THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EPE EVERYDAY PRACTICAL ELECTRONICS

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HIGH-QUALITY AUDIO SIGNAL GENERATOR – PART 1

- Five waveforms: sine, square, triangle and two sawtooth
- Frequency range: 1Hz to 24/48kHz in 1Hz steps
- TOSLINK, S/PDIF digital outputs
- Two analogue audio outputs
- Sinewave harmonic distortion typically <0.06%

ACCURATE THERMOMETER/THERMOSTAT

Using Dallas' DS18B20 sensor, it provides accurate readings to one decimal point

WIN A MICROCHIP 16-bit Explorer Board

Solar-Powered Alarm

SOLAR-POWERED INTRUDER ALARM

Is your garage, garden shed or even your boat safe?

PLUS

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MARCH 2012 PRINTED IN THE UK

Microcontrollers

Digital Signal Controllers

Analog

Memory

RF & Wireless

New 8-bit Microcontrollers with integrated configurable logic in 6- to 20-pin packages

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PIC10F322
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Comms
ADC
PIC16F1509
CPU
PWM
CLC
CWG
NCO
MICROCHIP
PIC12F1501
MICROCHIP
PIC16LF1503

Microchip's new PIC10F/LF32X and PIC12/16F/LF150X 8-bit microcontrollers (MCUs) let you add functionality, reduce size, and cut the cost and power consumption in your designs for low-cost or disposable products, with on-board Configurable Logic Cells (CLCs), Complementary Waveform Generator (CWG) and Numerically Controlled Oscillator (NCO).

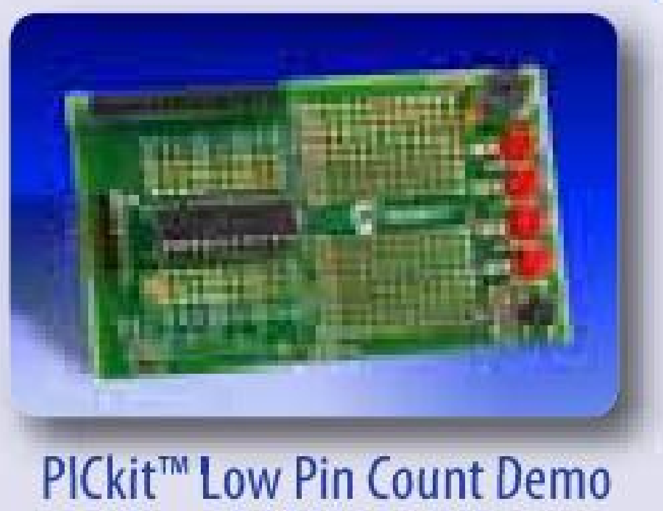
The Configurable Logic Cells (CLCs) give you software control of combinational and sequential logic, to let you add functionality, cut your external component count and save code space. Then the Complementary Waveform Generator (CWG) helps you to improve switching efficiencies across multiple peripherals; whilst the Numerically Controlled Oscillator (NCO) provides linear frequency control and higher resolution for applications like tone generators and ballast control.

PIC10F/LF32X and PIC12/16F/LF150X MCUs combine low current consumption, with an on-board 16MHz internal oscillator, ADC, temperature-indicator module, and up to four PWM peripherals. All packed into compact 6- to 20-pin packages.

FAST-START DEVELOPMENT TOOLS

PICDEM™ Lab Development Kit - DM163045

PIC16F193X 'F1' Evaluation Platform - DM164130-1



PICkit™ Low Pin Count Demo Board - DM164120-1

Free CLC Configuration Tool:
www.microchip.com/get/euclctool

Go to www.microchip.com/get/eunew8bit to find out more about low pin-count PIC® MCUs with next-generation peripherals

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● NEWS ● COMMENT ●
● POPULAR FEATURES ●
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Our April 2012 issue will be published on Thursday 1 March 2012, see page 72 for details.

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Leads: Parallel (LDC136) £3.95 / Serial (LDC441) £3.95 / USB (LDC644) £2.95

USB & Serial Port PIC Programmer

USB/Serial connection. Header cable for ICSP. Free Windows XP software. See website for PICs supported. ZIF Socket and USB lead extra. 18Vdc.
Kit Order Code: 3149EKT - **£49.95**
Assembled Order Code: AS3149E - **£59.95**
Assembled with ZIF socket Order Code: AS3149EZIF - **£74.95**

USB Flash/OTP PIC Programmer

USB PIC programmer for a wide range of Flash & OTP devices—see website for details. Free Windows Software. ZIF Socket and USB lead not included. Supply: 16-18Vdc.
Assembled Order Code: AS3150 - **£49.95**
Assembled with ZIF socket Order Code: AS3150ZIF - **£64.95**

ATMEL 89xxxx Programmer

Uses serial port and any standard terminal comms program. 4 LED's display the status. ZIF sockets not included. Supply: 16Vdc.
Kit Order Code: 3123KT - **£28.95**
Assembled Order Code: AS3123 - **£39.95**

Introduction to PIC Programming

Go from complete beginner to burning a PIC and writing code in no time! Includes 49 page step-by-step PDF Tutorial Manual, Programming Hardware (with LED test section), Win 3.11—XP Programming Software (Program, Read, Verify & Erase), and 1rewritable PIC16F84A that you can use with different code (4 detailed examples provided for you to learn from). PC parallel port.
Kit Order Code: 3081KT - **£16.95**
Assembled Order Code: AS3081 - **£24.95**

PIC Programmer Board

Low cost PIC programmer board supporting a wide range of Microchip® PIC™ microcontrollers. Requires PC serial port. Windows interface supplied.
Kit Order Code: K8076KT - **£39.95**

PIC Programmer & Experimenter Board

The PIC Programmer & Experimenter Board with test buttons and LED indicators to carry out educational experiments, such as the supplied programming examples. Includes a 16F627 Flash Microcontroller that can be reprogrammed up to 1000 times for experimenting at will. Software to compile and program your source code is included.
Kit Order Code: K8048KT - **£39.95**
Assembled Order Code: VM111 - **£59.95**

Controllers & Loggers

Here are just a few of the controller and data acquisition and control units we have. See website for full details. 12Vdc PSU for all units: Order Code PSU303 £9.95

USB Experiment Interface Board

5 digital input channels and 8 digital output channels plus two analogue inputs and two analogue outputs with 8 bit resolution.
Kit Order Code: K8055KT - **£39.95**
Assembled Order Code: VM110 - **£64.95**

Rolling Code 4-Channel UHF Remote

State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 Tx's can be learnt by one Rx (kit includes one Tx but more available separately). 4 indicator LED 's. Rx: PCB 77x85mm, 12Vdc/6mA (standby). Two *& Ten Channel versions also available.*
Kit Order Code: 3180KT - **£54.95**
Assembled Order Code: AS3180 - **£64.95**

Computer Temperature Data Logger

Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 45x45mm. Powered by PC. Includes one DS1820 sensor.
Kit Order Code: 3145KT - **£24.95**
Assembled Order Code: AS3145 - **£31.95**
Additional DS1820 Sensors - **£4.95 each**

Remote Control Via GSM Mobile Phone

Place next to a mobile phone (not included). Allows toggle or auto-timer control of 3A mains rated output relay from any location with GSM coverage.
Kit Order Code: MK160KT - **£14.95**

Most items are available in kit form (KT suffix) or pre-assembled and ready for use (AS prefix).

4-Ch DTMF Telephone Relay Switcher

Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 130 x 110 x 30mm. Power: 12Vdc.
Kit Order Code: 3140KT - **£79.95**
Assembled Order Code: AS3140 - **£94.95**

8-Ch Serial Port Isolated I/O Relay Module

Computer controlled 8 channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Includes plastic case 130x100x30mm. Power: 12Vdc/500mA.
Kit Order Code: 3108KT - **£74.95**
Assembled Order Code: AS3108 - **£89.95**

Infrared RC 12–Channel Relay Board

Control 12 onboard relays with included infrared remote control unit. Toggle or momentary. 15m+ range. 112 x 122mm. Supply: 12Vdc/0.5A
Kit Order Code: 3142KT - **£64.95**
Assembled Order Code: AS3142 - **£74.95**

Audio DTMF Decoder and Display

Detect DTMF tones from tape recorders, receivers, two-way radios, etc using the built-in mic *or* direct from the phone line. Characters are displayed on a 16 character display as they are received and up to 32 numbers can be displayed by scrolling the display. All data written to the LCD is also sent to a serial output for connection to a computer. Supply: 9-12V DC (Order Code PSU303). Main PCB: 55x95mm.
Kit Order Code: 3153KT - **£37.95**
Assembled Order Code: AS3153 - **£49.95**

3x5Amp RGB LED Controller with RS232

3 independent high power channels. Preprogrammed or user-editable light sequences. Standalone option and 2-wire serial interface for microcontroller or PC communication with simple command set. Suitable for common anode RGB LED strips, LEDs and incandescent bulbs. 56 x 39 x 20mm. 12A total max. Supply: 12Vdc.
Kit Order Code: 3191KT - **£27.95**
Assembled Order Code: AS3191 - **£37.95**

Everyday Practical Electronics
FEATURED KITS

March 2012

Everyday Practical Electronics Magazine has been publishing a series of popular kits by the acclaimed Silicon Chip Magazine Australia. These projects are 'bullet proof' and already tested Down Under. All Jaycar kits are supplied with specified board components, quality fibreglass tinned PCBs and have clear English instructions. Watch this space for future featured kits.

Ultrasonic Antifouling for Boats

KC-5498 £90.50 plus postage & packing

Marine growth electronic antifouling systems can cost thousands. This project uses the same ultrasonic waveforms and virtually identical ultrasonic transducers mounted in a sturdy polyurethane housings. By building it yourself (which includes some potting) you save a fortune! Standard unit consists of control electronic kit and case, ultrasonic transducer, potting and gluing components and housings. The single transducer design of this kit is suitable for boats up to 10m (32ft); boats longer than about 14m will need two transducers and drivers. Basically all parts supplied in the project kit including wiring. (Price includes epoxies).

- 12VDC
- Suitable for power or sail
- Could be powered by a solar panel/wind generator
- PCB: 104(L) x 78(W)mm

Featured in EPE January 2012

Now available Pre-built:

Dual output, suitable for vessels up to 14m (45ft)
YS-5600 £309.25
Quad output, suitable for vessels up to 20m (65ft)
YS-5602 £412.25

240V 10A Deluxe Motor Speed Controller Kit

KC-5478 £36.25 plus postage & packing

The deluxe motor speed controller kit allows the speed of a 240VAC motor to be controlled smoothly from near zero to full speed. The advanced design provides improved speed regulation and low speed operation. Also features soft-start, interferences suppression, fuse protection and over-current protection. Kit supplied with all parts including pre-cut metal case.

- PCB: 112(L) x 142(W)mm

Note: Requires UK mains socket or adaptor
Featured in EPE November 2011

Minimaximite Controller Kit

KC-5505 £18.25 plus postage & packing

A versatile and intelligent controller to interface with your creations, such as home automation. Features 20 configurable digital/analog I/O ports, 128K RAM and 256KB flash memory to hold your program and data. Design and test in MMBasic over a USB link from your PC, then disconnect the PC and the programs continue to operate. Alternatively, hard wire a PC monitor, keyboard, SD card reader and amplified speaker to work independent of a PC.

- Requires 2.3 - 3.6VDC (2 x AA or use plugpack MP-3310 £7.00)
- Kit supplied with PCB, pre-programmed and pre-soldered micro, and electronic components
- PCB: 78(L) x 38(W)mm

NEW

Featured in EPE December 2011

G-Force Meter Kit

KC-5504 £18.25 plus postage & packing

Measure the g-forces on your vehicle and it's occupants during your next lap around the race circuit, or use this kit to encourage smoother driving to save petrol and reduce wear & tear. Forces (+/- 2g) are displayed on the 4-digit LED display. Also use it to measure g-forces on a boat crashing over waves or on a theme park thrill ride. Kit includes PCB with pre-mounted SMD component, pre-programmed microcontroller and all onboard electronic components.

- Requires 2 x AA batteries
- PCB: 100(L) x 44(W)mm

Note: We supply the PCB with the SMD component already mounted on the board to save time and frustration.

NEW

Featured in EPE November 2011

Digital Audio Delay Kit

KC-5506 £36.25 plus postage & packing

Corrects sound and picture synchronization ("lip sync") between your modern TV and home theatre system. Features an adjustable delay from 20 to 1500ms in 10ms steps, and handles Dolby Digital AC3, DTS and linear PCM audio with sampling rate of up to 48kHz. Connections include digital S/PDIF and optical Toslink connections, and digital processing means there is no audio degradation. Kit includes PCB with overlay and pre-soldered SMD IC, enclosure with machined panels, and electronic components.

- 9-12VDC power supply required
- Universal IR remote required - use AR-1729 £8.75
- PCB: 103(L) x 118(W)mm

NEW

Featured in EPE August 2011

Courtesy Interior Light Delay Kit

KC-5392 £7.50 plus postage & packing

Many modern cars feature a time delay on the interior light. It still allows you time to buckle up and get organised before the light dims and finally goes out. This kit provides that feature for cars which don't already provide it. It has a soft fade out after a set time has elapsed, and features a much simpler universal wiring than our previous models.

- Kit supplied with PCB with overlay, and all electronic components.
- Suitable for circuits switching ground or +12V or 24VDC
- PCB: 78(L) x 46(W)mm

Featured in EPE August 2011

Voltage Monitor Kit

KC-5424 £8.50 plus postage & packing

This versatile kit will allow you to monitor the battery voltage, the airflow meter or oxygen sensor in your car. The kit features 10 LEDs that illuminate in response to the measured voltage, preset 9-16V, 0.-5V or 0-1V ranges, complete with a fast response time, high input impedance and auto dimming for night time driving. Kit includes PCB with overlay, LED bar graph and all electronic components.

- 12VDC
- PCB: 74(L) x 47(W)mm

Featured in EPE September 2010

Stereo Compressor Kit

KC-5507 £21.75 plus postage & packing

Compressors are useful in eliminating the extreme sound levels during TV ads, "pops" from microphones when people speak or bump / drop them, leveling signals when singers or guitarist vary their level, etc. Kit includes PCB, processed case and electronic components for 12VDC operation. 12VDC plug pack required - use MP-3147 £6.25

NEW

Featured in EPE January 2012

45 Second Voice Recorder Module

KC-5454 £12.75 plus postage & packing

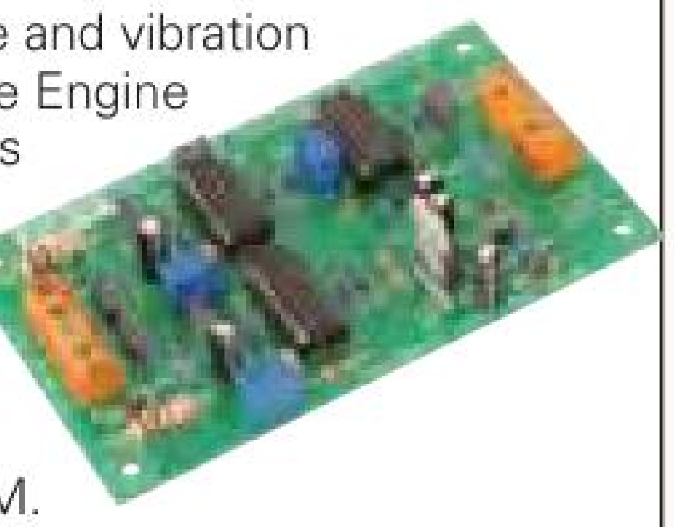
This kit has been improved and can now be set up easily to record two, four or eight different messages for random-access playback or a single message for 'tape mode' playback. Also, it now provides cleaner and glitch-free line-level audio output suitable for feeding an amplifier or PA system. It can be powered from any source of 9-14VDC.

- Supplied with silk screened and solder masked PCB and all electronic components
- PCB: 120(L) x 58(W)mm

Featured in EPE February 2011

Marine Engine Speed Equaliser Kit

KC-5488 £14.50 plus postage & packing



Avoid unnecessary noise and vibration in twin-engine boats. The Engine Speed Equaliser Kit takes the tacho signals from each motor and displays the output on a meter that is centred when both motors are running at the same RPM. When there's a mismatch, the meter shows which motor is running faster and by how much. Simply adjust the throttles to suit. Short form kit only, requires moving coil panel meter (QP-5010 £6.25).

- 12VDC
- Kit supplied with PCB, and all electronic components
- PCB: 105(L) x 63(W)mm

Featured in EPE November 2011

433MHz Remote Switch Kit

KC-5473 £16.50 plus postage & packing

The receiver has momentary or toggle output and the momentary period can be adjusted. Up to five receivers can be used in the same vicinity. Short-form kit contains two PCBs and all specified components.

- 200m range
- Extra transmitter kit sold separately : KC-5474 $8.50
- Requires case and 9-12VDC
- PCB: Tx: 85 x 63mm Rx: 79 x 48mm

Featured in EPE January 2011

Jaycar Electronics

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All modules assembled & tested.

Digital Echo Chamber Kit
A compact sound effects kit, with built-in mic or line in, line out or speaker (500mW). 4 Adjustment controls
Power: 9Vdc 150mA
MK182 Velleman kit £11.43

3rd Brake Light Flasher Kit
Works with any incandescent or LED rear centre brake light. Flashes at 7Hz for 5 or 10 times, adjustable retriggering.
Power: 12Vdc max load 4A
MK178 Velleman kit £6.30

Digital Clock Mini Kit
Red 7 Segment display in attractive enclosure, automatic time base selection, battery back-up, 12 or 24Hr modes.
Power: 9Vac or dc
MK151 Velleman kit £15.09

Proximity Card Reader Kit
A simple security kit with many applications. RFID technology activates a relay, either on/off or timed. Supplied with 2 cards, can be used with up to 25 cards. Power: 9Vac or dc
MK179 Velleman kit £14.25

Running Microbug Kit
Powered by two subminiature motors, this robot will run towards any light source. Novel shape PCB with LED eyes.
Power: 2 x AAA Batteries
MK127 Velleman kit £9.02

200W Power Amplifier
A high quality audio power amp, 200w music power @ 4Ω 3-200kHz Available as a kit without heatsink or module including heatsink.
K8060 Velleman kit £12.85
Heatsink for kit £9.95
VM100 Module £38.54

MP3 Player Kit
Plays MP3 files from an SD card, supports ID3 tag which can be displayed on optional LCD. Line & headphone output. Remote control add-on. Power: 12Vdc 100mA
K8095 Velleman kit £39.99

DC to Pulse width Modulator
A handy kit to accurately control DC motors etc. Overload & short circuit protection. Input voltage 2.5-35Vdc, Max output 6.5A.
Power: 8-35Vdc
K8004 Velleman kit £9.95

Audio Analyser Kit
A small spectrum analyser with LCD. Suitable for use on 2, 4 or 8Ω systems. 300mW to 1200W(2Ω) 20-20kHz Panel mounting, back-lit display. Power: 12Vdc 75mA
K8098 Velleman kit £31.65

USB DMX Interface
512 DMX Channels controlled by PC via USB. Software & case included. Available as a kit or ready assembled module.
K8062 Velleman kit £47.90
VM116 Module £67.15

USB Interface Board
Featuring 5 in, 8 digital outputs, 2 in & 2 analogue outputs. Supplied with software. Available as a kit or ready assembled module.
K8055 Velleman kit £24.80
VM110 Module £34.90

8 Channel USB Relay Board
PC Controlled 16A relays with toggle, momentary or timed action. Test buttons included, available in a kit or assembled.
K8090 Velleman kit £39.95
VM8090 Module £58.40

Multifunction Up/Down Counter
An up or down counter via on-board button or ext input. Time display feature. Alarm count output. 0-9999 display.
Power: 9-12Vdc 150mA
K8035 Velleman kit £17.85

Nixie Clock Kit
Gas filled nixie tubes with their distinctive orange glow. HH:MM display, automatic power sync 50/60Hz
Power: 9-12Vac 300mA
K8099 Velleman kit £64.96

Mini USB Interface Board
New from Velleman this little interface module with 15 inputs/outputs inc digital & analogue in, PWM outputs. USB Powered 50mA, Software supplied
VM167 Module £26.80

Thermostat Mini Kit
General purpose low cost thermostat kit. +5 to +30°C Easily modified temperature range/min/max/hysteresis 3A Relay
Power: 12Vdc 100mA
MK138 Velleman Kit £4.55

Velleman Function Generator
PC Based USB controlled function generator. 0.01Hz to 2Mhz Predefined & waveform editor. Software supplied. See web site for full feature list.
PCGU1000 Velleman £118.38

Velleman PC Scope
PC Based USB controlled 2 channel 60Mhz oscilloscope with spectrum analyser & Transient recorder. 2 Scope probes & software included. See web site for full feature list.
PCSU1000 Velleman £249.00

Velleman PC Scope/Generator
PC Based USB controlled 2 channel oscilloscope AND Function generator. Software included. See web site for full feature list.
PCSGU250 Velleman £113.67

RF Remote Control Transmitter
Single channel RF keyfob transmitter with over 13,122 combinations. Certified radio frequency 433.92MHz.
Power: 12Vdc 2mA (inc) For use with TL-1,2,3,4 receivers.
TL-5 Cebek Module £14.64

RF Remote Control Receiver
Single channel RF receiver with relay output. Auto or manual code setup. Momentary output, 3A relay
Power: 12Vdc 60mA For use with TL-5 or TL-6 transmitters.
TL-1 Cebek Module £28.25

Keypad Access Control
An electronic lock with up to ten 4 digit codes. Momentary or timed (1-60ec/1-60min) output. Relay 5A
Power: 12Vdc 100mA Keypad included.
DA-03 Cebek Module £54.26

AC Motor Controller
A 230Vac 375W motor speed control unit giving 33 to 98% of full power.
Power: 230Vac
R-8 Cebek Module £12.14

Digital Record/Player
Non volatile flash memory, Single 20 sec recording via integral mic, 2W output to 8Ω speaker.
Power: 5Vdc 100mA
C-9701 Cebek Module £7.89

2 Digital Counter
Standard counter, 0 to 99 from input pulses or external signal. With reset input, 13.5mm Displays,
Power: 12Vdc 90mA.
CD-9 Cebek Module £12.99

1.8W Mono Amplifier
Compact mono 1.8W RMS 4Ω power stage, short circuit & reverse polarity protection. 30-18kHz, Power: 4-14Vdc 150mA
E-1 Cebek Module £5.87

20W 2 Channel Amplifier
Mono amplifier with 2 channels (Low & High frequecy), 20W RMS 4Ω per channel, adjustable high level. 22-22kHz, short circuit & reverse polarity protection.
Power: 8-18Vdc 2A
E-14 Cebek Module £22.11

5W Stereo Amplifier
Stereo power stage with 5W RMS 4Ω, 30-18kHz, short circuit & reverse polarity protection.
Power: 6-15Vdc 500mA
ES-2 Cebek Module £21.54

12Vdc Power Supply
Single rail regulated power supply complete with transformer. 130mA max, low ripple, 12Vdc with adjustment.
FE-103 Cebek Module £13.16

1-180 Second Timer
Universal timer with relay output. Time start upon power up or push button. LED indication. 5A Relay
Power: 12Vdc 60mA
I-1 Cebek Module £12.92

Cyclic Timer
Universal timer with relay output. Time start upon power up or push button. On & Off times 0.3-60 Seconds, LED indication. 5A Relay
Power: 12Vdc 80mA
I-10 Cebek Module £14.12

Light Detector
Adjustable light sensor operating a relay. Remote sensor & terminals for remote adjustment pot. 5A Relay
Power: 12Vdc 60mA
I-4 Cebek Module £13.98

Liquid Level Detector
A liquid level operated relay. Remote sensor operates relay when in contact with a liquid. 5A Relay
Power: 12Vdc 60mA
I-6 Cebek Module £13.08

Thermostat
A temerature controlled relay. Adjustable between -10 to 60°C Sensor on remote PCB. Connector for external adjustment pot. 5A Relay
Power: 12Vdc 60mA
I-8 Cebek Module £12.80

Start / Stop Relay
Simple push button control of a relay. Either 1 or 2 button operation 5A Relay
Power: 12Vdc 60mA
I-9 Cebek Module £12.83

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Editorial Offices:
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EDITORIAL Wimborne Publishing Ltd., 113 Lynwood Drive, Merley, Wimborne, Dorset, BH21 1UU
Phone: (01202) 880299. **Fax:** (01202) 843233.
Email: enquiries@wimborne.co.uk
Website: www.epemag.com
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113 Lynwood Drive, Merley, Wimborne, Dorset, BH21 1UU
Phone: 01202 880299 **Fax:** 01202 843233
Email: stewart.kearn@wimborne.co.uk

Editor:	MATT PULZER
Consulting Editor:	DAVID BARRINGTON
Subscriptions:	MARILYN GOLDBERG
General Manager:	FAY KEARN
Graphic Design:	RYAN HAWKINS
Editorial/Admin:	(01202) 880299
Advertising and Business Manager:	STEWART KEARN (01202) 880299
On-line Editor:	ALAN WINSTANLEY
EPE Online (Internet version) **Editors:**	CLIVE (Max) MAXFIELD and ALVIN BROWN
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EPE EVERYDAY PRACTICAL ELECTRONICS

The future's bright, the future's raspberry

It's nice to write about some good news in the depths of winter; even better to report good news about British electronics and computing.

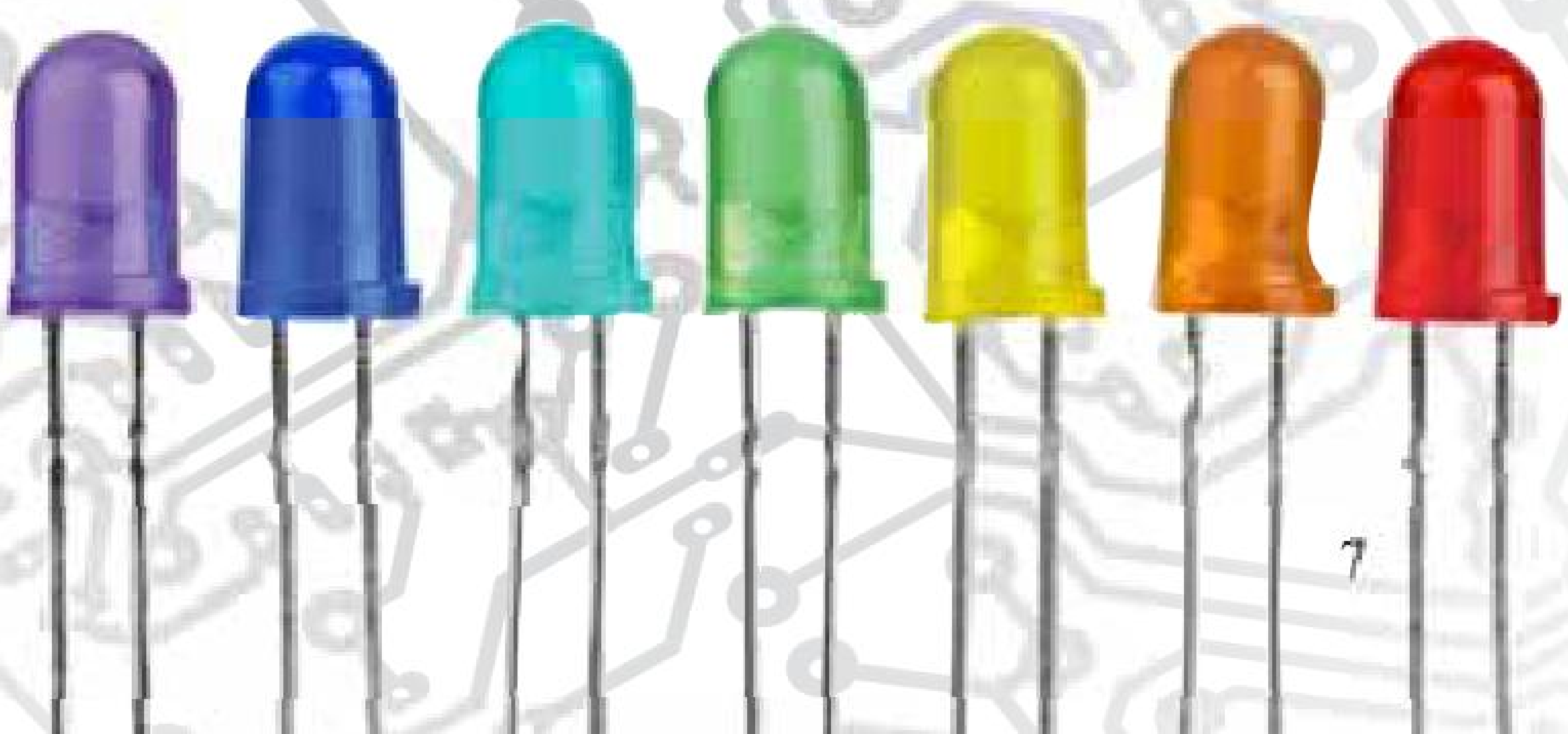
In the UK, in the early 1980s, there was an explosion of interest in home computing. This was largely driven by the arrival of affordable computers from Sinclair Research and the BBC. The Sinclair ZX80, ZX81 and, Spectrum, and the pricier, but more flexible BBC Model A and B computers sold by the millions. They found their way into classrooms, living rooms, teenagers' bedrooms and even university laboratories. By today's standards they were, to say the least, basic. The ZX80 base model had just one kilobyte of memory, and stored programs on audiocassette tape; but users didn't mind, they were just thrilled to get their hands on a 'real computer'.

Memory levels rose of course, but even the higher-end versions of the BBC Model B had only 64KB to 128KB of RAM. You might think this limited the usability of these computers, but quite the opposite happened; it spurred a whole generation of young software designers to experiment and to write tight, neat code to enable them to cram as much functionality as possible into a very limited space. Those coders, who cut their software teeth on cheap early computers, went on to help develop the British software industry, including areas where we are still world leaders, such as gaming.

Sadly, much of the momentum of the pioneering early 1980s has been eroded by the improvement of computers. Too much IT training in schools now consists of how to use word-processing software, and not how the software underpinning the wordprocessor or computer is actually designed and written.

This so concerned Cambridge researcher David Braben that he helped found (and now heads) the Raspberry Pi Foundation. Their product is the 'Raspberry Pi', a barebones computer on a credit-card-sized PCB at the remarkable price of just £15. It has a USB port for mouse/keyboard and an HDMI interface for plugging into a TV for display purposes. The idea is to give anyone, but especially interested children, the opportunity to play with and program a simple computer without worrying about cost, complex operating systems or all the other complications that come with using a conventional Windows, Apple OSX or Linux computer.

This is a brilliant British invention, which may well help to teach and inspire the next generation of computer engineers – more details of the Raspberry Pi are covered in the News pages.



NEWS

A roundup of the latest Everyday News from the world of electronics

Screen technology update by Barry Fox

Dolby's professional PRM-4200 monitor – not a tunerless consumer TV!

In the 1950s, Ray Dolby was one of the team at US electronics company Ampex, which developed the world's first practical video recorder. But it was his own company, Dolby Labs, that made its name with audio tape noise reduction. Dolby Labs then changed the face of cinema sound with surround systems and moved on and into digital cinema, with content servers for digital projectors.

Dolby 3D, with technology bought in from German company Infitec, uses slightly modified colour spectra to separate the left and right eye images, instead of polarisation. But colour separation glasses are far more expensive than passive polarising spectacles, and Dolby 3D is seldom now on offer at local cinemas.

In the meantime, Dolby Labs has been developing a new approach to LCD screen design. The PRM-4200 42-inch LCD screen was designed to replace Hi Def CRT monitors as a reference monitor in post-production houses. The 1920 × 1080 full-HD panel is guaranteed to have no dead pixels when factory fresh, and is back-lit by 4500 individual LEDs, arranged in 1500 red, green, blue triads. The LEDS are dimmed in sync with the screen display to give a contrast ratio of 40,000:1, and results in a striking difference between bright whites and dark blacks.

This compares with the few hundred individually dimmed groups of LEDs or 'sectors' in even the most expensive consumer TVs.

Demo footage of gaily-dressed snowboarders airlifted by a stunt helicopter to mountain peaks and then racing down near vertical slopes shows off the contrast, with near-3D effects.

The monitor has HD-SDI coaxial inputs for digital video, because HDMI cannot cope with the video switching and long cable runs, of up to 100 metres, needed in production suites.

The PRM-4200 costs $40,000, but Dolby knows this would not deter some well-heeled consumers. However, showing off their display technology at consumer shows would involve Dolby in explaining why the screen cannot be used with a Blu-ray player that works only with copy-protected HDMI connections. HD-SDI connections are unprotected and considered safe only for professional use. Says a Dolby spokesman: 'The monitor is a professional product not a TV. But people keep asking us why we don't build in a tuner…'

3D TV advertising ruling

By the time you read this, the Advertising Standards Authority (ASA) should finally have adjudicated on a six-month running dispute over consumer 3D TV. The ASA's Council was due to meet on 20 January to try and make a final decision on Samsung's complaint against adverts for passive 3D TV published by LG Electronics in July 2011.

The process has been lengthy and a special meeting is needed, says the ASA's investigations executive, because 'the Council has considered this case and wishes to discuss it in full in order to make a decision… because it is likely that any decision will result in a precedent being set for full-HD claims for passive 3D TVs'.

LG's adverts were headed: *'It's 3D TV (but not as we know it)'*, and promoted 'the world's first flicker free TV with HD 1080p enhanced picture quality, giving you a screen that's clearer and twice as bright as conventional 3D TVs… with ultra wide viewing so more of your family and friends can get in on the action.'

Samsung complained, and for nearly six months the ASA has been evaluating arguments, counter-arguments and expert opinion.

Both LG and Samsung have so far avoided comment on the dispute. However, LG's UK website currently claims that, 'Our 3D glasses… give you a stunning full-HD 3D picture' and 'the LG CINEMA 3D TV produces a brighter and clearer picture in stunning full-HD 3D picture quality.' See: **www.lg.com/uk/cinema3d/cinema3d/index.jsp**

In Times Square in New York recently, an LG billboard screen has been taunting the opposition: 'In 3D TV tests, four out of five people chose LG Cinema 3D over Sony and Samsung. Hey, Sony and Samsung, better stick to 2D'.

Biofuel insect power

An insect's internal chemicals can be converted to electricity, potentially providing power for sensors, recording devices or to control the bug, a group of researchers at Case Western Reserve University in the US report.

The finding is yet another in a growing list from universities that could bring the creation of insect cyborgs – touted as possible 'first responders' to 'super spies' – out of science fiction and into reality. In this case, the power supply, while small, doesn't rely on movement, light or batteries, just normal feeding.

'It is virtually impossible to start from scratch and make something that works like an insect,' said Daniel Scherson, chemistry professor at Case Western Reserve.

'Using an insect is likely to prove far easier,' Scherson said. 'For that, you need electrical energy to power sensors or to excite the neurons to make the insect do as you want, by generating enough power out of the insect.'

Scherson's university team has developed an implantable biofuel cell to provide usable power. The key to converting the chemical energy is using enzymes in series at the anode. The result is current flow, as electrons are drawn to the fuel cell's cathode, where oxygen from air takes up the electrons and is reduced to water.

In tests, prototype electrodes were inserted in a blood sinus in the abdomen of a female cockroach, away from critical internal organs. The researchers found the cockroaches suffered no long-term damage, which bodes well for long-term use.

To determine the output of the fuel cell, the group used an instrument called a potentiostat. Maximum power density reached nearly 100μW/cm^2 at 0.2V. Maximum current density was about 450μA/cm^2.

The researchers are now taking several steps to move the technology forward: miniaturising the fuel cell so that it can be fully implanted and allow an insect to run or fly normally; investigating materials that may last long inside an insect; working with other researchers to build a signal transmitter that can run on little energy; and adding a lightweight rechargeable battery.

'It's possible the system could be used intermittently,' Scherson said. 'An insect equipped with a sensor could measure the amount of noxious gas in a room, broadcast the finding, shut down and recharge for an hour, then take a new measurement and broadcast again.'

GRAPHENE BATTERY

Researchers at Chicago's Northwestern University have demonstrated experimental lithium ion batteries that, they claim, will hold a charge up to 10 times greater than currently possible; they also charge ten times faster. Clusters of silicon are sandwiched between graphene sheets to allow a greater number of lithium atoms in the anode, while the graphene is 'perforated' for faster recharging. The technology could be ready for commercial use in the next three to five years, the university states.

ARM compilers from MikroElektronika

MikroElektronika has launched new ARM compilers, which together with development boards and Visual TFT Software complete MikroElektronika's ARM Cortex-M3 toolchain.

Over 50 libraries have been included in the release, which aims to boost efficiency, cut development time and providing reliable, fast and easy-to-use solutions. More information is available on the ARM compilers webpage: ***www.mikroe.com/eng/categories/view/96/arm-compilers***

Tiny memory

IBM has announced an experimental memory device consisting of just 12 atoms – a research record.

MAKING A RASPBERRY Pi

Raspberry Pi, the new, British credit-card-sized computer that plugs into a TV and keyboard (see this month's editorial) has commenced production, according to the website of the backing organisation. This capable computer can be used for many of the things a desktop PC does, but the stated aim of the cheap device is to 'see it being used by kids all over the world to learn programming'.

Two models are being launched: Model A ($25) and Model B ($35).

The device measures 86mm x 54mm x 17mm, with a little overlap for the SD card and connectors that project over the edges. It weighs in at just 45g.

Mice, keyboards, network adapters and external storage will all connect via a USB hub. It includes a composite and HDMI out on the board, so it can be hooked up to a digital or analogue television, or to a DVI monitor. There is no VGA support, but adaptors are available.

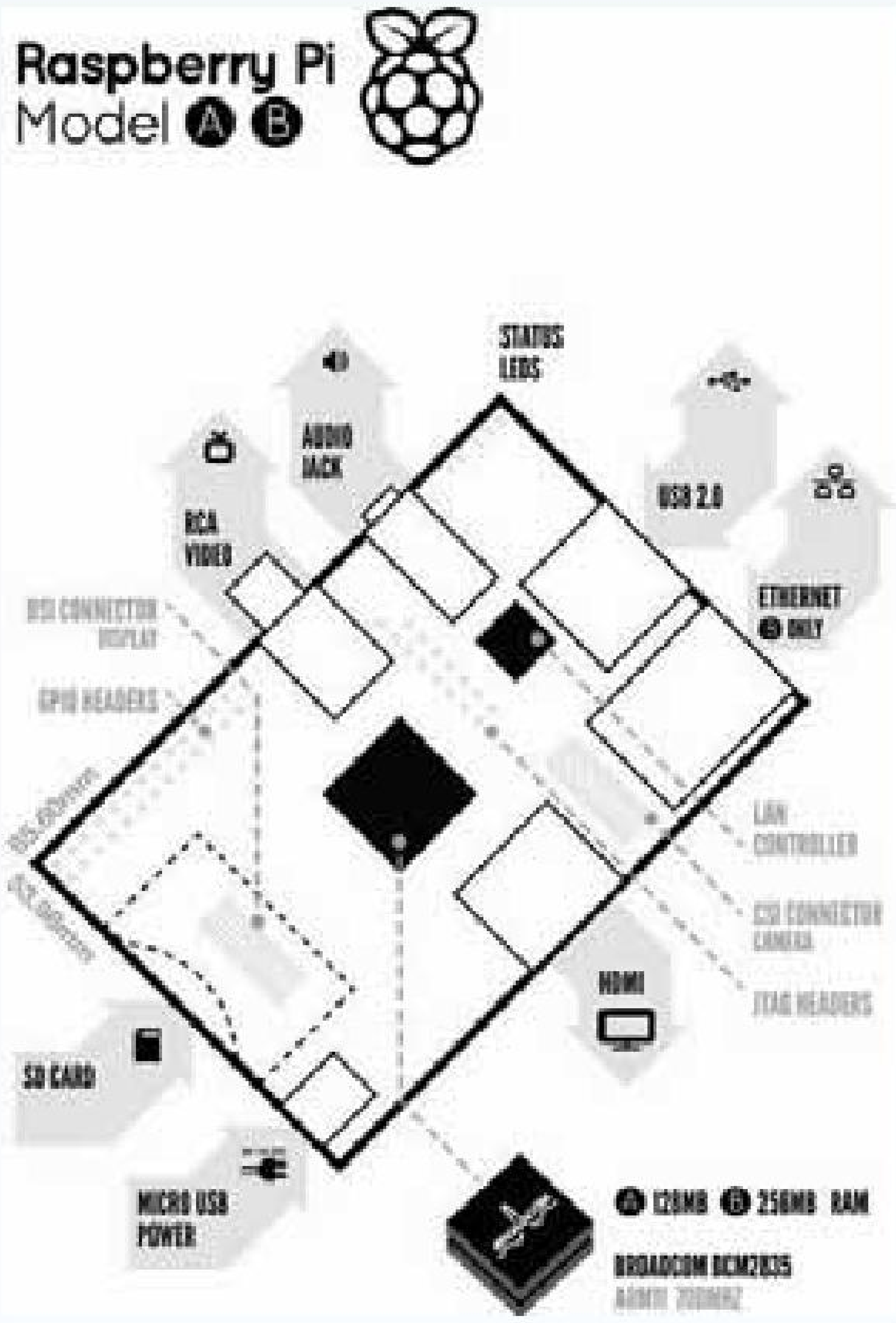
Audio out is supported via a standard 3.5mm jack, or HDMI. A USB microphone can be added via the hub.

The Model B version includes 10/100 wired Ethernet. There is no Ethernet on the Model A version, but Wi-Fi will be available via a standard USB dongle.

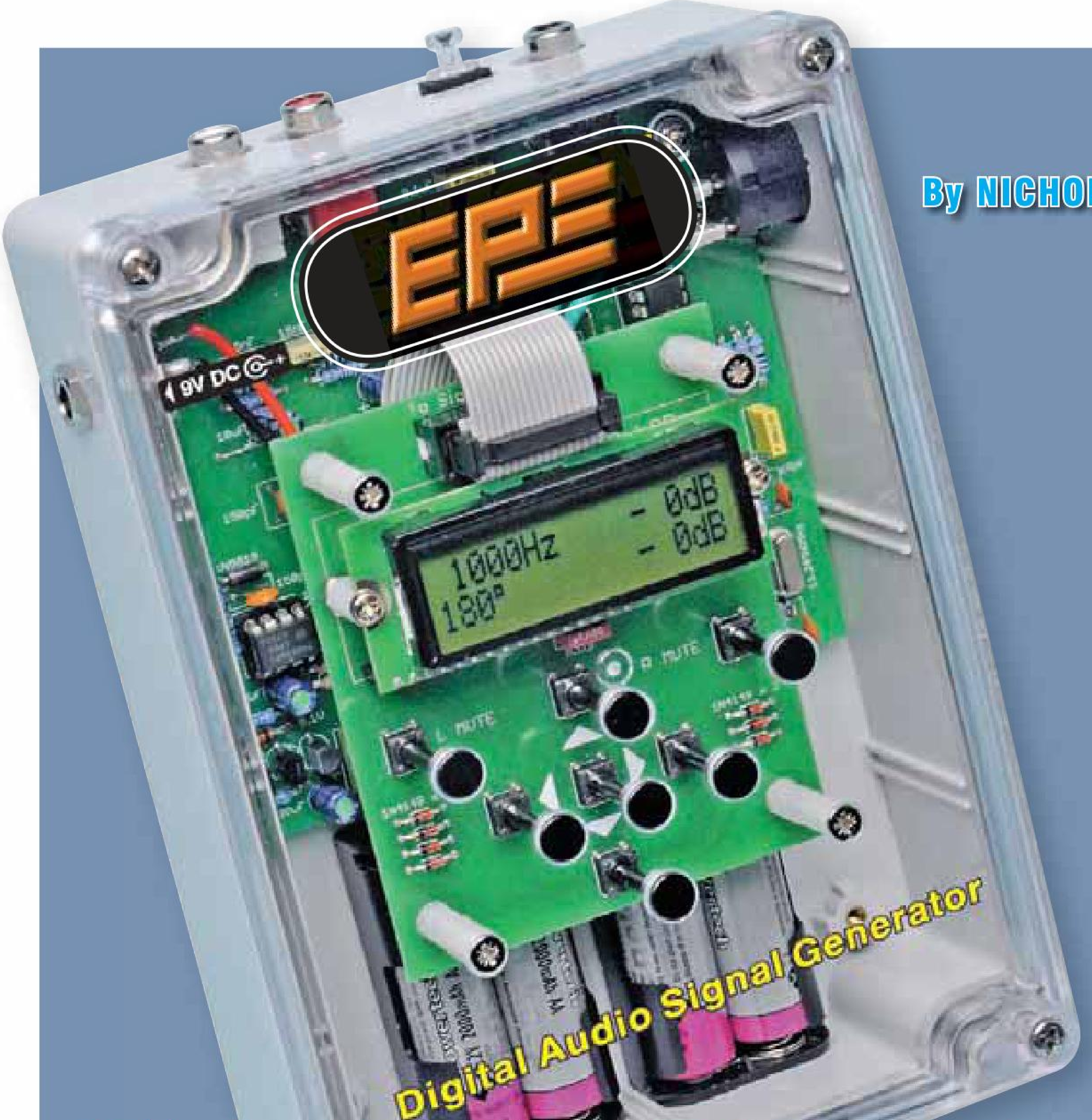
There is a useful Wiki at: ***http://elinux.org/Rasp berryPiBoard****, where users can find a beginner's guide, FAQs and details of future Raspberry Pi-related events.*

Further relevant information, including a lively and enthusiastic community forum is available at: ***www.raspberrypi.org****.*

Last, but not least, Raspberry Pi is a charitable organisation that has already generated considerable good will. The first ten boards were auctioned on eBay, where a generous bidder paid £3500 for board number one as a way of donating funds to this educational charity.



Main architecture of the Raspberry Pi credit card-sized PC


9V DC
1000Hz
- 0dB
- 0dB
180°
L MUTE
R MUTE
Digital Audio Signal Generator

By NICHOLAS VINEN

High-Quality Digital Audio Signal Generator – Part 1

This Digital Audio Signal Generator has TOSLINK and coax (S/PDIF) digital outputs, as well as two analogue audio outputs. If a digital output is used, the harmonic distortion from a high quality DAC is extremely low. Alternatively, if you use the analogue outputs, the harmonic distortion of the sinewave signal is typically still very low at less than 0.06%.

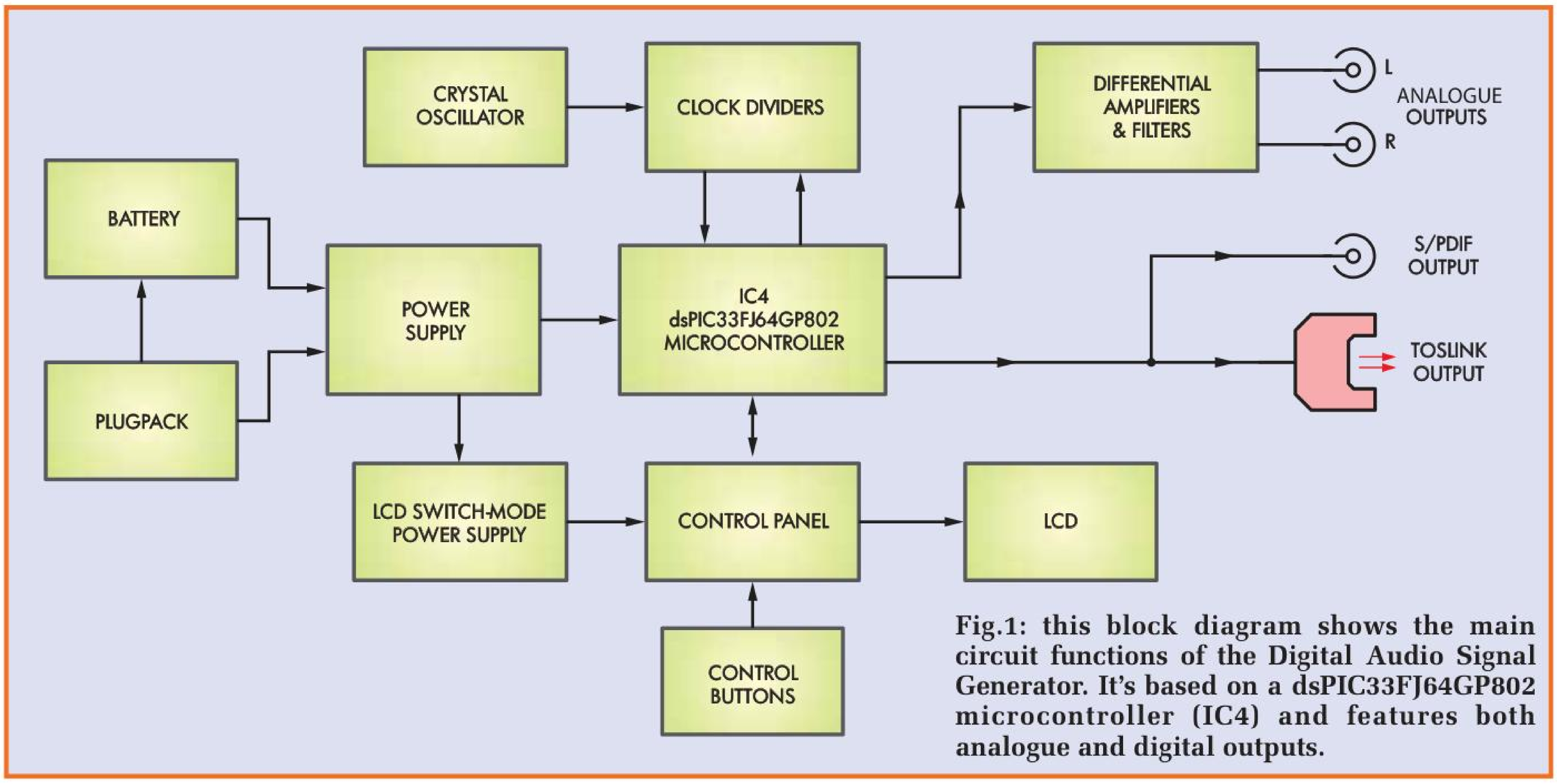


Fig.1: this block diagram shows the main circuit functions of the Digital Audio Signal Generator. It's based on a dsPIC33FJ64GP802 microcontroller (IC4) and features both analogue and digital outputs.

S/PDIF Audio Generator: Main Features

- Five waveform types supported: sine, square, triangle and two sawtooth
- Frequency range: 1Hz to 24kHz in 1Hz steps at 48kHz sampling rate, or 1Hz to 48kHz at 96kHz sampling rate (see text)
- Five waveform generation modes and four output modes (see Table 1 and Table 2)
- Runs off a plugpack (9V to 10V DC) or a battery (4 × AA or AAA cells).
- Built-in battery voltage monitor with settable low battery voltage warning
- Status display for pulse and sweep modes, to show amplitude and frequency
- Sweep can be manually triggered or paused/resumed/restarted
- Digital output can be switched between 'consumer' (S/PDIF, 20-bit data) and 'professional' (AES/EBU, 24-bit data) modes
- Can enable pre-emphasis bit on digital output if desired
- 10 setting banks for storing modes and configuration
- Digital LCD contrast and backlight brightness control

AS WELL as sinewave outputs with low distortion, this Digital Audio Signal Generator produces a range of other waveforms which you would normally only obtain from a (pricey) high-quality function generator. These waveforms include square, triangle and sawtooth, as well as advanced functions such as waveform mixing, pulse and sweep modes.

If you connect the SPDIF digital output to our high-quality Stereo Digital-to-Analogue Converter (DAC), (*EPE*, September to November 2011), you get a sinewave output with very low distortion in the audio band. We measured around 0.0006% THD+N (20Hz to 22kHz bandwidth) for a 1kHz full-scale sinewave, with a sampling rate of 48kHz and less than 0.001% THD+N for any frequency between 20Hz and 2kHz.

Distortion

The distortion is less than 0.006% up to 20kHz (or 0.005% with a sampling rate of 96kHz). That is lower distortion than from most commercial audio generators that we know of.

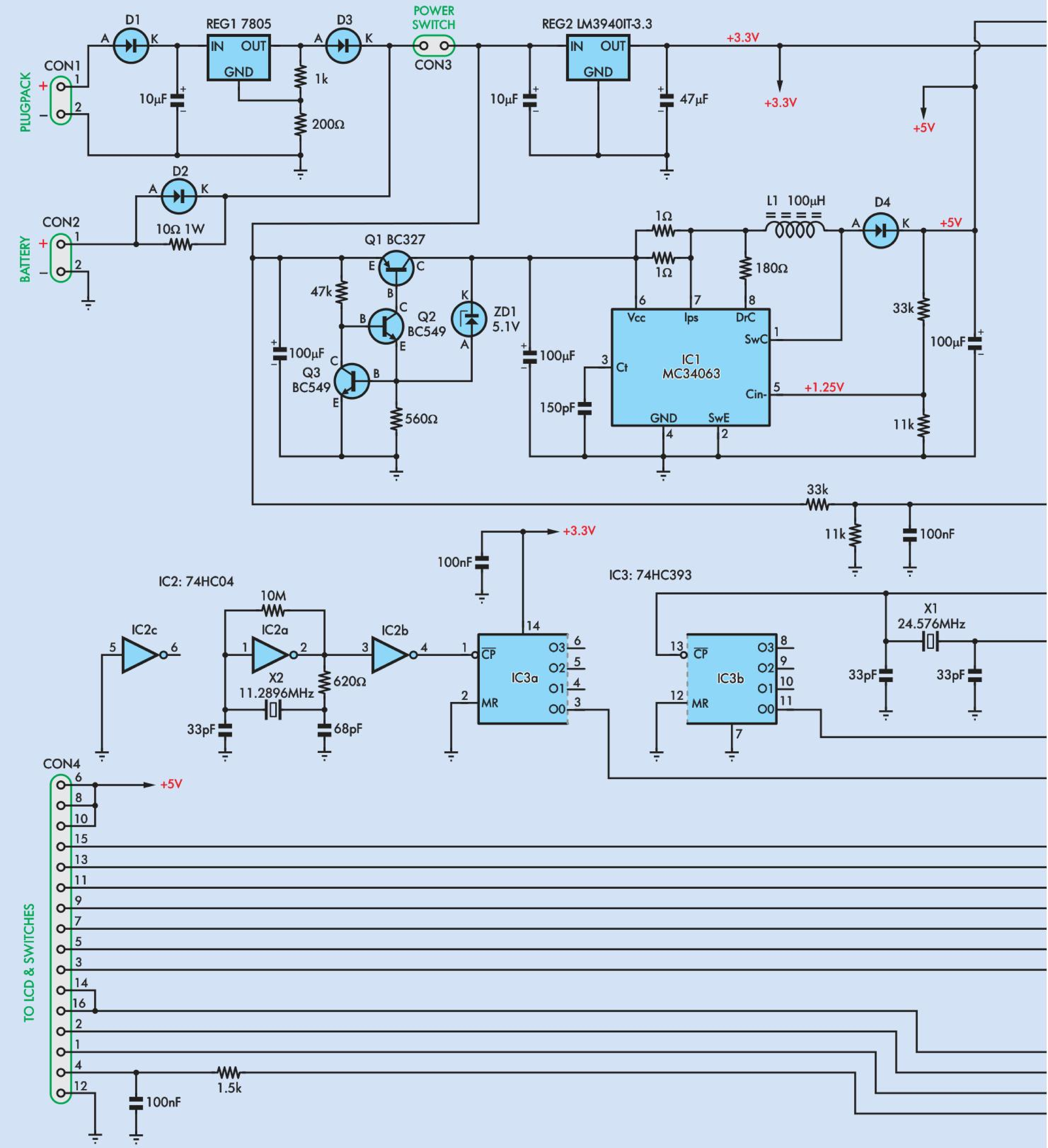
There is one important proviso. Using a DAC for signal generation means that there will be high-frequency switching noise in the output. This is true whether you use an external DAC, or the internal one that drives the analogue outputs.

Usually, this will not be an issue, however it is important to keep it in mind. If you use the signal as part of a noise or distortion test, the measuring equipment will need to be able to ignore residuals above 20kHz.

Features

Five waveform types are supported: sine, square, triangle and sawtooth up/down. Both analogue channels always produce the same waveform, although the frequencies and amplitudes are independently adjustable. In certain modes, frequency or amplitude are fixed between the two channels. However, they can always be individually muted.

The available frequency range is 1Hz to 24kHz in 1Hz steps at the default sampling rate of 48kHz. You can increase the sampling rate to 96kHz, and the upper frequency limit is then 48kHz. If you set the sampling rate to the third option, 44.1kHz, the upper frequency limit is 22.05kHz. These are the Nyquist frequencies – the highest frequency that can be digitally represented at that sampling rate.


CON1
PLUGPACK
+
–
1
2
D1
A
K
REG1 7805
IN
OUT
GND
10µF
1k
200Ω
D3
POWER SWITCH
CON3
REG2 LM3940IT-3.3
10µF
47µF
+3.3V
+3.3V
+5V
D2
10Ω 1W
CON2
BATTERY
Q1 BC327
E
C
B
47k
Q2 BC549
Q3 BC549
100µF
ZD1 5.1V
560Ω
100µF
150pF
1Ω
1Ω
L1 100µH
D4
+5V
180Ω
IC1 MC34063
Vcc
Ips
DrC
SwC
Ct
Cin-
GND
SwE
6
7
8
1
3
5
4
2
+1.25V
33k
11k
100µF
33k
11k
100nF
+3.3V
100nF
IC2: 74HC04
IC3: 74HC393
10M
IC2c
IC2a
IC2b
X2 11.2896MHz
620Ω
33pF
68pF
IC3a
CP
MR
O3
O2
O1
O0
14
IC3b
13
12
7
X1 24.576MHz
33pF
33pF
CON4
+5V
TO LCD & SWITCHES
6
8
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11
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100nF
1.5k

S/PDIF & TOSLINK DIGITAL AUDIO SIGNAL GENERATOR

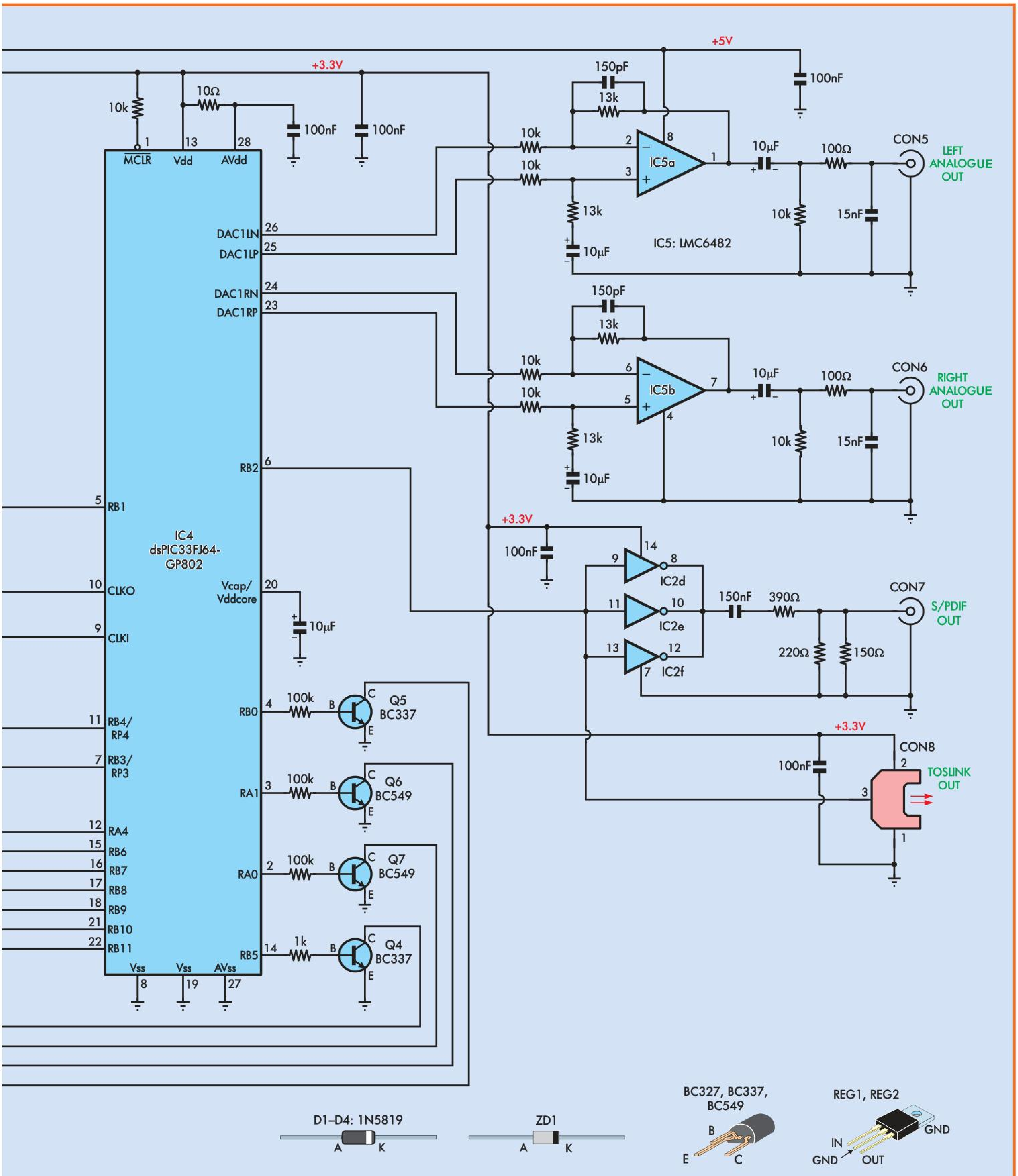

+5V
+3.3V
10k
10Ω
100nF
100nF
1
13
28
MCLR
Vdd
AVdd
150pF
13k
100nF
10k
10k
2
3
8
IC5a
1
10μF
100Ω
CON5
LEFT ANALOGUE OUT
13k
10μF
10k
15nF
IC5: LMC6482
DAC1LN 26
DAC1LP 25
DAC1RN 24
DAC1RP 23
150pF
13k
10k
10k
6
5
IC5b
7
4
10μF
100Ω
CON6
RIGHT ANALOGUE OUT
13k
10μF
10k
15nF
RB2 6
5 RB1
IC4
dsPIC33FJ64-GP802
10 CLKO
9 CLKI
Vcap/ Vddcore 20
10μF
+3.3V
100nF
14
9
8
IC2d
11
10
IC2e
13
12
7
IC2f
150nF
390Ω
CON7
S/PDIF OUT
220Ω
150Ω
+3.3V
CON8
100nF
2
3
1
TOSLINK OUT
11 RB4/ RP4
7 RB3/ RP3
12 RA4
15 RB6
16 RB7
17 RB8
18 RB9
21 RB10
22 RB11
RB0 4
100k
Q5
BC337
RA1 3
100k
Q6
BC549
RA0 2
100k
Q7
BC549
RB5 14
1k
Q4
BC337
B
C
E
Vss 8
Vss 19
AVss 27
D1–D4: 1N5819
A
K
ZD1
A
K
BC327, BC337, BC549
B
E
C
REG1, REG2
GND
IN
GND
OUT

Fig.2: the circuit diagram for the main PC board. REG1, REG2 and IC1 are the main power supply components, while IC2 and IC3 generate the clock signals. IC4 performs the signal generation and also interfaces to the LCD board. Pin 23 to pin 26 drive op amps IC5a and IC5b to produce the analogue signals, while pin 6 drives the TOSLINK and S/PDIF outputs.

Table 1: Waveform generation modes

Mode	Features
Locked	Single frequency, adjustable phase difference between the left and right channels
Independent	Different frequencies can be output on the left and right channels
Mixed	Mixes signals of two different frequencies and amplitudes, output on both channels
Pulsed	Amplitude alternates between two values with configurable on/off delays
Sweep	Frequency varies over time, ramping up/down over specified time period

Table 2: Output modes

Sampling Rate	Outputs enabled	Comment
44.1kHz	Digital (S/PDIF) only	CD quality
48.0kHz	Digital (S/PDIF) and Analogue	DVD quality
96.0kHz	Digital (S/PDIF) only	DVD-audio, etc
96.0kHz	Analogue only	Highest quality analogue

Frequency accuracy and stability are limited by the crystals used, so it should generally be within 50 parts per millions (ppm) or 0.005% at 25°C – a typical crystal frequency tolerance. Over a wider range of temperatures, the drift might be up to 100ppm (0.01%). This translates to an actual 1kHz frequency of between 999.9Hz and 1000.1Hz. We measured 999.95Hz from our prototype.

The output amplitude ranges from 0dB to –98dB in 1dB steps, as well as an 'off' setting in place of –99dB. Amplitude accuracy is good, with a –90dB 1kHz sinewave actually being measured as –89.37dB using our Audio Precision System One. If you use the analogue outputs, the 0dB amplitude level is close to 1V RMS. Alternatively, if you use the recommended external DAC, 0dB translates to around 2V RMS, with much lower distortion.

Waveform generation modes

There are five main waveform generation modes to choose from (Table 1) and four output modes (Table 2). Taken together, the waveform type, waveform generation and output modes make for a total of 100 different mode combinations. Any generation mode can be combined with any waveform type, although you can't have different waveform types on each channel.

Table 4 gives specific information on each waveform generation mode.

Circuit details

The general details of the unit are shown in the block diagram of Fig.1. As is usual with a project of this complexity, it is based on a high performance PIC microcontroller, IC4. This generates the digital and analogue output signals, in response to commands from the control panel pushbuttons. It also drives the LCD panel. Note that there are two digital outputs: TOSLINK and S/PDIF coaxial.

Turning to the full circuit diagram for the Digital Audio Signal Generator, see Fig.2, IC4 can be seen to be a dsPIC33FJ64GP802 16-bit digital signal controller. This microcontroller runs at up to 40MHz and has 64KB of Flash program/data memory and 16KB of random access memory (RAM).

Because it's a 16-bit processor, it can manipulate much larger numbers than an 8-bit microcontroller, improving its efficiency in dealing with audio data. Its data converter interface (DCI), internal digital-to-analogue converter (DAC) and direct memory access (DMA) support are all especially useful for this project.

Power supplies

The dsPIC33 runs off 3.3V, which is provided by an LM3940IT-3.3 low drop-out linear regulator (REG2). This ensures that the microcontroller can run with cells developing as little as 0.9V each (3.6V total), by which time most of the energy has been extracted from them. You shouldn't drain NiMH cells this low, but it's OK with alkaline or dry cells.

The rest of the power supply is a little more involved. We need 5V for the LCD and its backlight. Because the battery voltage could be above 5V (with NiMH cells being charged or fresh primary cells) or below 5V (NiMH cells being discharged or flat primary cells), the LCD supply needs to be able to increase or decrease its input voltage. We deliberately kept it simple by combining a discrete low drop-out linear regulator with a switchmode boost regulator. This keeps size and cost down, and uses readily available parts while retaining reasonable efficiency.

The discrete linear regulator consists of three transistors (Q1 to Q3), Zener diode ZD1 and two resistors. While it does not have particularly good load regulation, its dropout is very low (around 0.1V), which means that when the battery voltage is below 5V it doesn't waste much power.

It is followed by the boost regulator, which is built around IC1, an MC34063 switchmode DC-DC converter. It switches power through the inductor at around 100kHz, keeping the output at 5V.

This ensures that the LCD continues running as long as the microcontroller

Applications

- RMS and music power testing for power amplifiers
- Speaker placement optimisation
- Sub-woofer or speaker crossover optimisation
- Finding faults in audio equipment
- Audio quality testing for analogue or digital audio equipment with appropriate measurement equipment (THD, SNR, channel separation, intermodulation distortion, frequency response)
- Analogue circuit prototyping and development
- Testing DACs or other equipment that accept a digital audio signal
- Whenever you need an adjustable audio-frequency signal source.

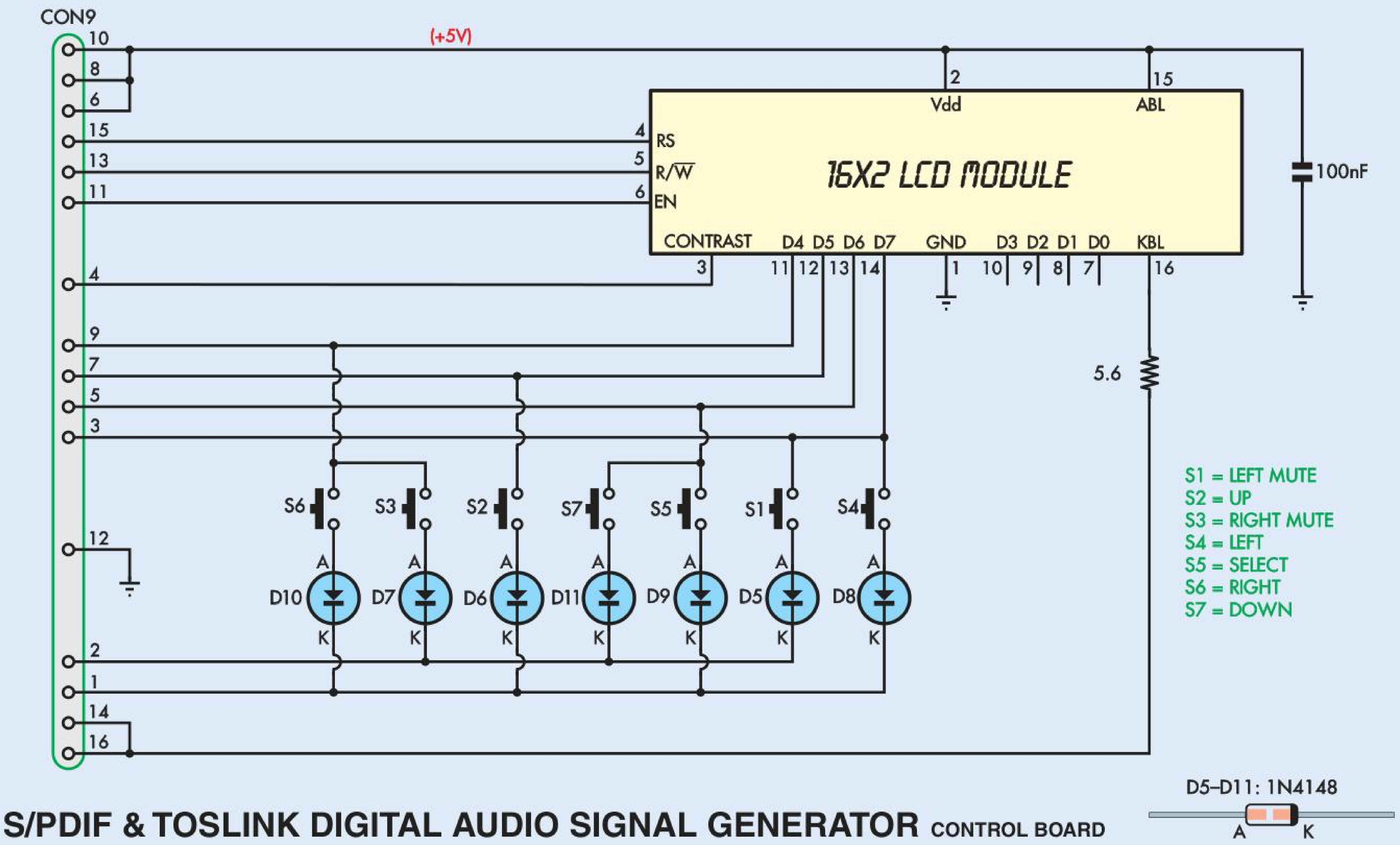


Fig.3: the control board circuit. It consists of a 16×2 LCD module, plus pushbutton switches S1 to S7 and isolating diodes D5 to D11. The microcontroller (IC4) on the main board reads the switch states and updates the display.

does. It also keeps the LCD backlight brightness and contrast constant as the cells discharge.

The 7805 regulator (REG1) is mainly there to protect the LM3940IT-3.3 (REG2) from voltages above its maximum rating (7.5V). The 1kΩ and 200Ω resistors associated with REG1 are used to increase its output to around 6.8V, ensuring that it always exceeds the battery voltage. That way, the battery cannot be drained when the plugpack is connected and it also allows rechargeable cells to be kept charged reasonably well.

Clock generators

There are two oscillators to produce the three sampling clocks. One runs at 11.2896MHz (44.1kHz × 256), while the other runs at 24.576MHz (96kHz × 256). The 48kHz rate is generated within the microcontroller by halving the 96kHz clock.

While the 11.2896MHz crystal (X2) has its own oscillator circuit (driven by IC2a, one section of a 74HC04 hex inverter), the 24.576MHz crystal (X1) uses the dsPIC33's internal oscillator amplifier. It has a dual purpose – to generate the clock for 96kHz sampling, and also to provide the dsPIC's system clock.

Fortunately, it's easy to configure the dsPIC's internal PLL (phased-locked loop) to derive 39.936MHz from the 24.576MHz crystal, which is close enough to its 40MHz operating limit. As a result, the microcontroller is able to shut down the 24.576MHz oscillator if the battery is flat to save some power.

The 74HC393 ripple counter, IC3, has two purposes. First, it divides the oscillator frequencies to the S/PDIF encoding clock frequency we need, 5.6448MHz and 12.288MHz, which is 128 times the sampling rate in each case. Second, it ensures that the clocks have a 50% duty cycle.

Digital outputs

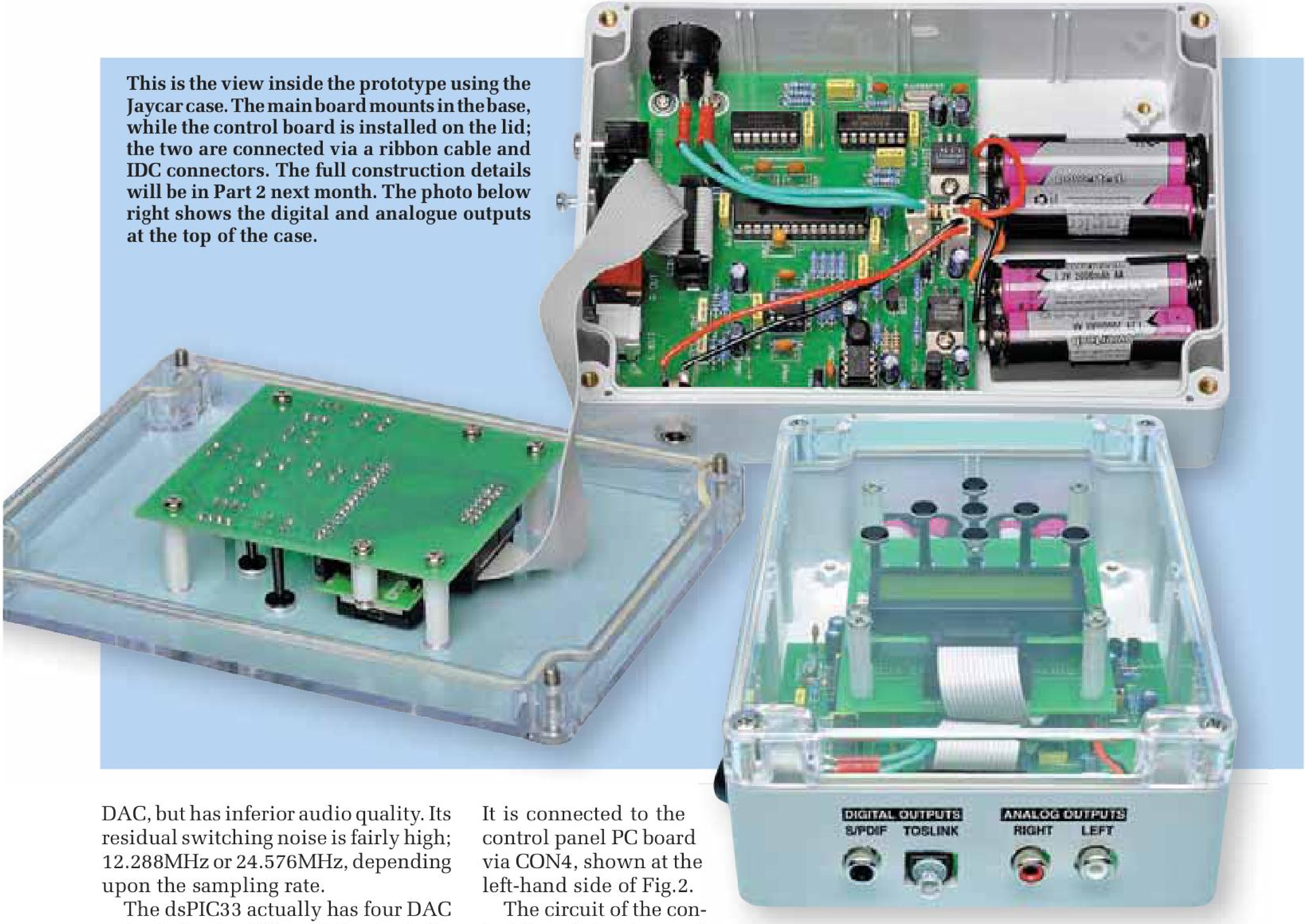
The digital audio signal is fed to both TOSLINK (optical) and coaxial outputs. For the optical output, the signal from the microcontroller's DCI (data conversion interface) is sent directly to the TOSLINK transmitter (CON8). For coaxial, we use three inverters from IC2, connecting them in parallel to buffer the signal, which is then coupled via the 150nF capacitor and fed to a resistive divider to produce the correct voltage and impedance levels for S/PDIF signals.

Analogue outputs

The dsPIC's internal DAC is a delta-sigma type. It's much like the Stereo

Table 3: Performance

Measurement @ 1kHz, SR = 48kHz, BW = 20Hz-20kHz	Internal DAC	External DAC
THD+N	0.06%	0.0006%
Signal-to-noise ratio	–66dB	–111dB
Channel separation	–66dB	–107dB
Attenuation at 20Hz	–0.07dB	–0.013dB
Attenuation at 20kHz	–0.67dB	–0.177dB
Attenuation at 40kHz (SR = 96kHz)	–1.6dB	–2.4dB



This is the view inside the prototype using the Jaycar case. The main board mounts in the base, while the control board is installed on the lid; the two are connected via a ribbon cable and IDC connectors. The full construction details will be in Part 2 next month. The photo below right shows the digital and analogue outputs at the top of the case.

DAC, but has inferior audio quality. Its residual switching noise is fairly high; 12.288MHz or 24.576MHz, depending upon the sampling rate.

The dsPIC33 actually has four DAC output pins, ie, differential outputs for the left and right channels. As recommended in the dsPIC33 data sheet, a pair of op amps is used to make the conversion from differential to single-ended outputs. In fact, we have used an LMC6482, a dual CMOS rail-to-rail amplifier (IC5), for this task, to get the best signal quality from the limited supply rail of only 5V.

In order to remove most of the high-frequency switching noise, we have added two filter stages to the differential amplifier stages of IC5. The first is the active filter in the op amp feedback networks, comprising the 150pF capacitors and 13kΩ resistors. The second filter involves the passive filters (100Ω resistor and 15nF capacitor) after the 10µF output capacitors and just before the output connectors (two RCA phono sockets).

Control panel

All the components mentioned thus far are mounted on the main PC board. It is connected to the control panel PC board via CON4, shown at the left-hand side of Fig.2.

The circuit of the control board is shown in Fig.3. It accommodates the LCD module and seven pushbutton switches. The two boards are connected via a 16-wire ribbon cable with IDC headers, ie, from CON4 on Fig.2 to CON9 on Fig.3.

The LCD's backlight brightness and contrast are regulated by the microcontroller. The brightness is adjusted via transistor (Q4), which is pulse-width modulated (PWM) at 50kHz; increasing the duty cycle increases the brightness.

This not only allows you to adjust it as desired (via the relevant pushbutton) but also saves battery usage, because only a low-value (5.6Ω) current-limiting resistor is required. The default 25% duty cycle allows the LCD to be viewed under virtually any lighting condition, without being too much of a drain on the battery.

Contrast control is a little more tricky, since we need a variable current sink to adjust it properly. This too is achieved via a 50kHz PWM signal; from pin 4 of IC4 to the base of transistor Q5, which pulls current from the LCD display through a 1.5kΩ resistor.

If the resistor is switched on by Q5 for, say, 50% of the time, this makes the circuit roughly equivalent to a 3.0kΩ resistor. A 100nF capacitor filters this switching to provide a variable supply to the LCD between its V_{CC} and V_O pins.

Button multiplexing

While 28 pins on a microcontroller may seem like a lot, in reality it was difficult to wire up everything needed for this project. Of the 28 pins, nine are dedicated to power supply, the main oscillator or reset functions, leaving 17 general-purpose pins. After subtracting the signal generator and battery monitoring functions, we're left with only nine for both LCD communications and button sensing for the user interface.

Parts List – High-Quality Digital Audio Signal Generator

- 1 IP67 polycarbonate enclosure with transparent lid, size 171mm × 121mm × 55mm (Jaycar HB-6218)
- 2 16-pin IDC crimp connectors
- 1 4AA side-by-side battery holder with leads (or 2 × 2AA side-by-side battery holders)
- 1 SPST rocker switch (Jaycar SK0960 or miniature/sub-miniature toggle switch
- 2 4.8mm female spade crimp connectors (only if SK0960 switch or similar is used)
- 1 2.1mm bulkhead male DC power connector (Jaycar PS-0522)
- 1 300mm length of 16-way ribbon cable
- 1 300mm length of double-sided tape
- 1 300mm length of red medium duty hook-up wire
- 1 300mm length of black medium duty hook-up wire
- Optional: 4 × low self-discharge AA 2000mAh NiMH cells (Jaycar SB1750 × 2)
- Optional: 9V 500mA DC regulated plugpack, or 7.5V 500mA DC unregulated plugpack, with 2.1mm ID plug (nominal output 9.5V @ 250mA, acceptable range 9V to 11V)

Main Board

- 1 PC board, code 838, available from the *EPE PCB Service*, size 109mm × 102mm
- 1 100μH bobbin inductor with 2.54mm pin spacing (Jaycar LF-1102)
- 1 PC-mount RCA phono connector (black)
- 1 PC-mount RCA phono connector (white)
- 1 PC-mount RCA phono connector (red)
- 1 16-pin IDC socket
- 3 2-pin polarised headers
- 3 2-pin polarised header connectors
- 1 2-pin shorting block
- 6 M3 × 6mm machine screws
- 2 M3 nuts
- 2 M3 flat washers
- 2 M3 star washers
- 1 PC-mount TOSLINK transmitter (Jaycar ZL-3000)
- 1 28-pin narrow machine-tooled IC socket
- 2 14-pin machine-tooled IC sockets
- 2 8-pin machine-tooled IC sockets

Semiconductors

- 1 MC34063 switchmode DC-DC converter (IC1)
- 1 74HC04 hex inverter (IC2)
- 1 74HC393 dual 4-stage ripple counter (IC3)
- 1 Microchip dsPIC33FJ64GP802 programmed microcontroller (IC4)
- 1 LMC6482 dual op amp (IC5)
- 1 BC327 transistor (Q1)
- 2 BC337 transistors (Q4,Q5)
- 4 BC549 transistors (Q2,Q3, Q6,Q7)
- 1 LM7805T 5V regulator (REG1)
- 1 LM3940IT-3.3 or TS2940CZ-3.3 3.3V regulator (REG2)
- 4 1N5819 Schottky diodes (D1 to D4)
- 1 5.1V 1W zener diode (ZD1)

Crystals

- 1 24.576MHz crystal (HC-49, low profile if possible)
- 1 11.2896MHz crystal (HC-49, low profile if possible)

Capacitors

- 3 100μF 16V radial electrolytic
- 1 47μF 16V radial electrolytic
- 6 10μF 16V radial electrolytic
- 1 10μF 16V tantalum
- 1 150nF MKT polyester or polycarbonate
- 8 100nF MKT polyester or polycarbonate
- 2 15nF MKT polyester or polycarbonate
- 3 150pF ceramic
- 1 68pF ceramic
- 3 33pF ceramic

Resistors (0.25W, 1%)

- 1 10MΩ
- 3 100kΩ
- 1 47kΩ
- 2 33kΩ
- 4 13kΩ
- 2 11kΩ
- 7 10kΩ
- 1 1.5kΩ
- 2 1kΩ
- 1 620Ω
- 1 560Ω
- 1 390Ω
- 1 220Ω
- 1 200Ω
- 1 180Ω
- 1 150Ω
- 2 100Ω
- 1 10Ω
- 1 10Ω 1W
- 2 1Ω 0.6W 5%
- 7 0Ω (or wire links)

Control Board

- 1 PC board, code 839, available from the *EPE PCB Service*, size 87mm × 73mm
- 7 1N4148 diodes (D5 to D11)
- 1 100nF MKT polyester capacitor
- 1 5.6Ω resistor
- 1 0Ω resistor (or wire link)
- 1 16-character × 2-line alpha-numeric LCD with backlight (Jaycar QP-5512)
- 7 tactile pushbutton switches with long actuators
- 7 switch button caps
- 1 16-pin IDC socket
- 1 16-pin single row female header
- 1 16-pin single row male header
- 6 M3 × 9mm tapped nylon spacers
- 4 M3 × 12mm tapped nylon spacers
- 4 M3 × 6mm machine screws
- 4 M3 × 10mm countersunk machine screws
- 4 M3 × 15mm machine screws
- 2 M3 nuts

Note: the PC boards will be available as a pair – see PCB page in the next issue

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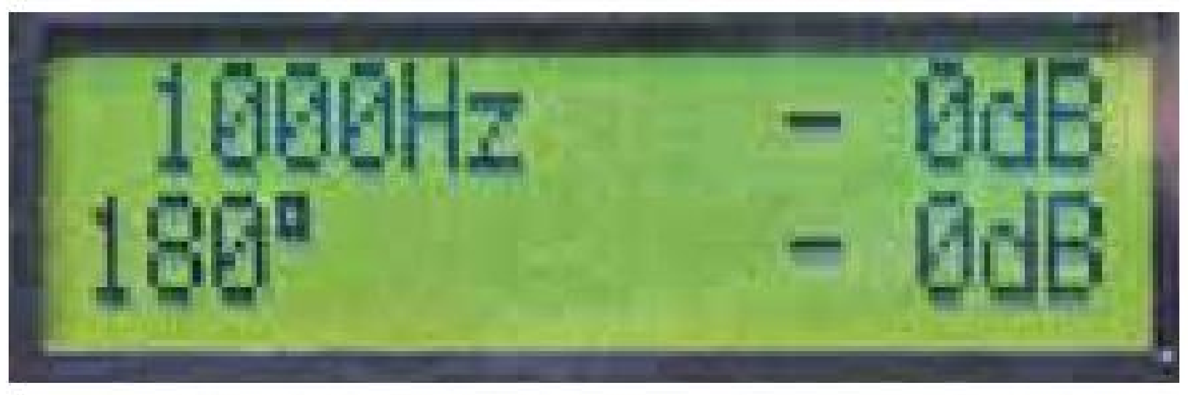
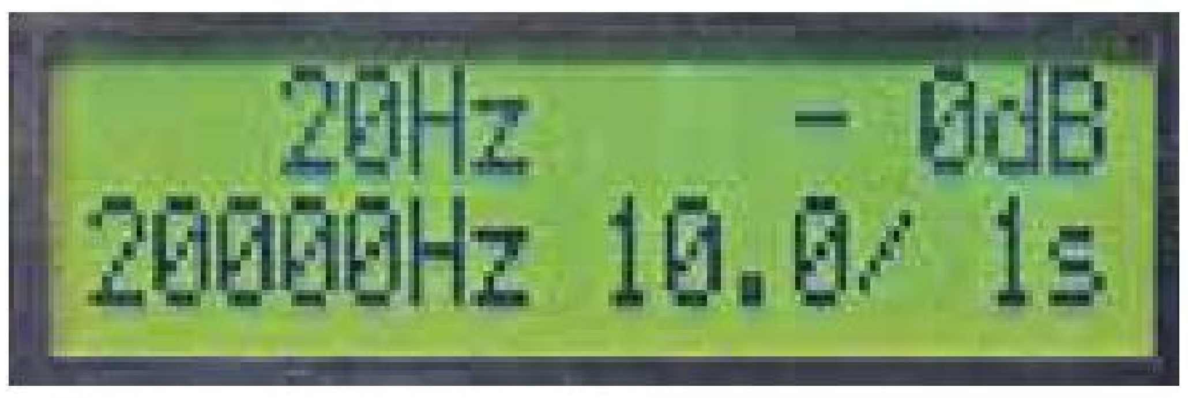
Communicating with the LCD without additional components requires at least seven pins, four for data I/O and three for control. Fortunately, there is a way to connect the seven buttons using the two remaining pins, by time-multiplexing the LCD I/O lines.

When there is no communication occurring with the LCD, its I/O lines are unused and are high impedance. So, we connect these four pins to one end of each of the seven buttons (six sharing three lines between them). The other side of each button is connected via 1N4148 diodes to transistors Q6 and Q7; the diodes are on Fig.3, while the transistors are on Fig.2.



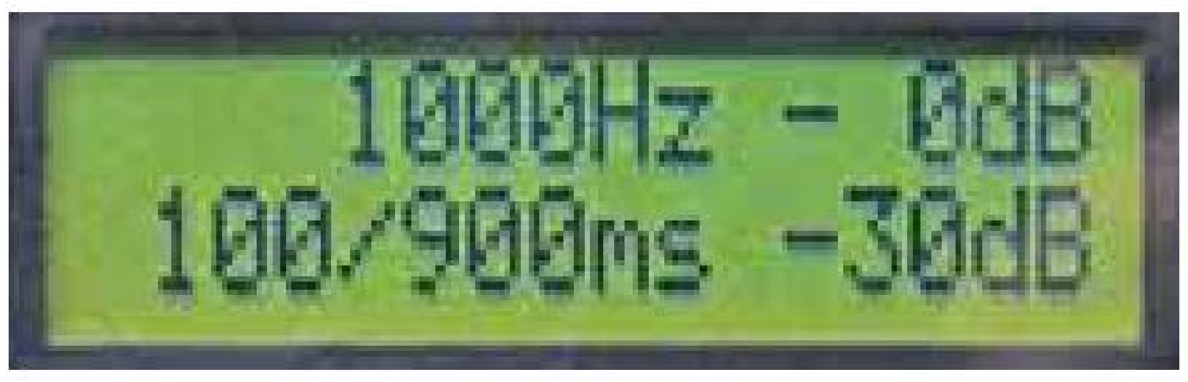
1000Hz - 0dB
180° - 0dB

Fig.4: the default Locked Mode display. The unit generates a 1kHz sinewave signal with a 180° phase difference between the two channels.



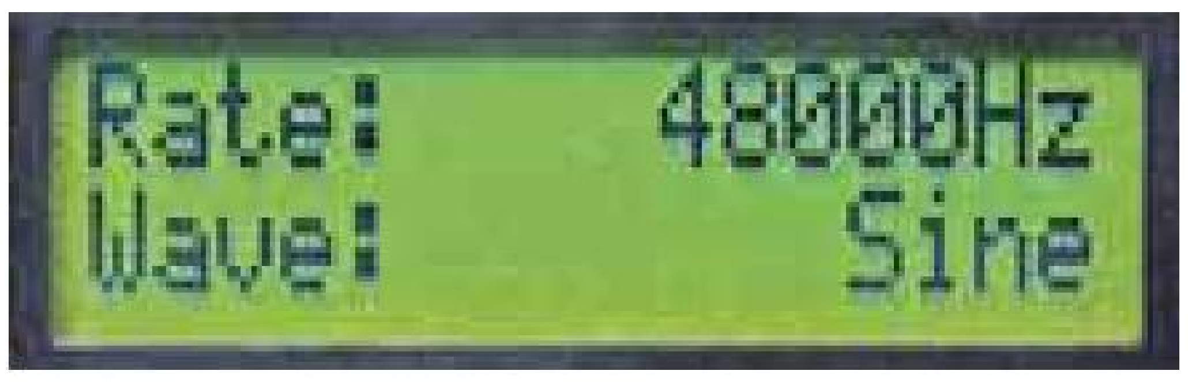
20Hz - 0dB
20000Hz 10.0/ 1s

Fig.5: the default Sweep Mode display. Both channels output a sinewave, which starts at 20Hz and ramps up to 20kHz over a 10s period.



1000Hz - 0dB
100/900ms -30dB

Fig.6: the default Pulsed Mode display. Both channels alternate between 0dB and –30dB amplitude each second (100ms high; 900ms low).



Rate: 48000Hz
Wave: Sine

Fig.7: the output/wave type setting display. In this case, the sampling rate is 48kHz and a sinewave is being generated.

When transistors Q6 and Q7 are switched off by the microcontroller, the diodes ensure that they do not affect the LCD I/O lines, regardless of whether any of the buttons are pressed. However, we can sense the button state when the transistors are turned on (one at a time) while we simultaneously enable the pull-up resistors on the four LCD I/O lines, pins 17, 18, 21 and 22 of IC4.

In this state, any button that is pressed will pull its corresponding I/O line low if its associated transistor is actively sinking current. Thus, we can periodically scan the buttons without affecting the LCD.

Battery charging

As mentioned earlier, nickel metal hydride (NiMH) rechargeable cells can be used to power the unit, and you can add a 10Ω 1W resistor to trickle charge them whenever the plugpack is connected. We've provided an appropriate mounting point on the PC board.

The final trickle charge current for an NiMH cell varies somewhat, but is typically between C/10 and C/40, ie 1/10th to 1/40th of its rated amp-hour capacity. We've set the resistor so that it provides a little under 100mA to the cells once they are fully charged, which equates to a rate of C/20 for 2000mAh cells. Keep in mind that the charge current will be appreciably higher than this when the cells are flat, as it decreases during charging.

If you use cells with a lower capacity than 2000mAh, then you need to increase the value of the resistor accordingly. For example, 800mAh cells would require a 27Ω 1W resistor, rather than the 10Ω resistor specified. For 600mAh cells, you would use 33Ω. We don't recommend you exceed C/20 for any NiMH cells.

Trickle charging is a lot slower than removing the cells and charging them 'properly', but it is more convenient. This is especially true if you will generally run the signal generator off mains power, with occasional battery use in-between. This way, the battery will always be ready for those times you need to take it into the field, or are away from a convenient power point. It also saves you the hassle of having to unscrew the lid to gain access to them.

Heat dissipation in the resistor will be kept under its 1W rating as long as the battery never goes below 3.6V. It's not a good idea to discharge NiMH cells to that extent anyway. If you do apply DC power with a battery below 3.6V, its voltage should rise rapidly and reduce the charge current to the safe range, but the best option in that case would be to remove the cells and then reinstall them once they have been properly charged.

If you install this resistor, you can *only use* NiMH or NiCad cells in the device. If you ever use alkaline or dry cells, *do not* install it, or they might overheat and leak if you accidentally plug it into DC power.

Software details

All software program files for the *Digital Audio Signal Generator* will be available from the *EPE* website at: **www.epemag.com**.

The software development for this project was complicated by the number of modes and features, and because all the modes have to run in real time up to the maximum 96kHz sampling rate. We were able to pack it all into the 64KB of Flash memory – but only just. The software consists of a number of modules:

- LCD display routines
- Button sensing and repeat logic
- Interface code – determines what to display on the LCD and how to react to button presses
- Digital and analogue output control
- Waveform generation (sine table lookup, linear interpolation, other waveform calculations)
- Output amplitude scaling
- Waveform generation modes (eg, mixed, sweep, pulsed)
- S/PDIF encoding
- Direct memory access (DMA) interrupt servicing
- Communication between the interface code and the waveform generator
- EEPROM emulation for storing settings in Flash memory (provided by Microchip)
- Battery monitoring and power saving

The interface code runs in the main loop, while all the waveform generation happens asynchronously in the DMA interrupt service routine (ISR). This way, the time-critical waveform generation has absolute priority.

If it did not provide the output data within a certain amount of time in all cases, the waveforms would be subject to glitches. In practice, this scheme works well because even though the interface only has a small percentage of the CPU time remaining to run, it is not an intensive task, so the delay is not noticeable.

What ties it all together is the communication code that passes data from the interface to the ISR. It is implemented so that changes in the output are as seamless as possible.

Simultaneous analogue and digital output is *only* available at the 48kHz sampling rate. This is because at 96kHz, we only have half as much time to generate the waveform data, and it's simply too slow to output both sets of data. We can't enable the analogue outputs at 44.1kHz either, because the DAC clock input is less flexible than the DCI's.

Real-time processing

With the microcontroller running at 40MHz and outputting audio data

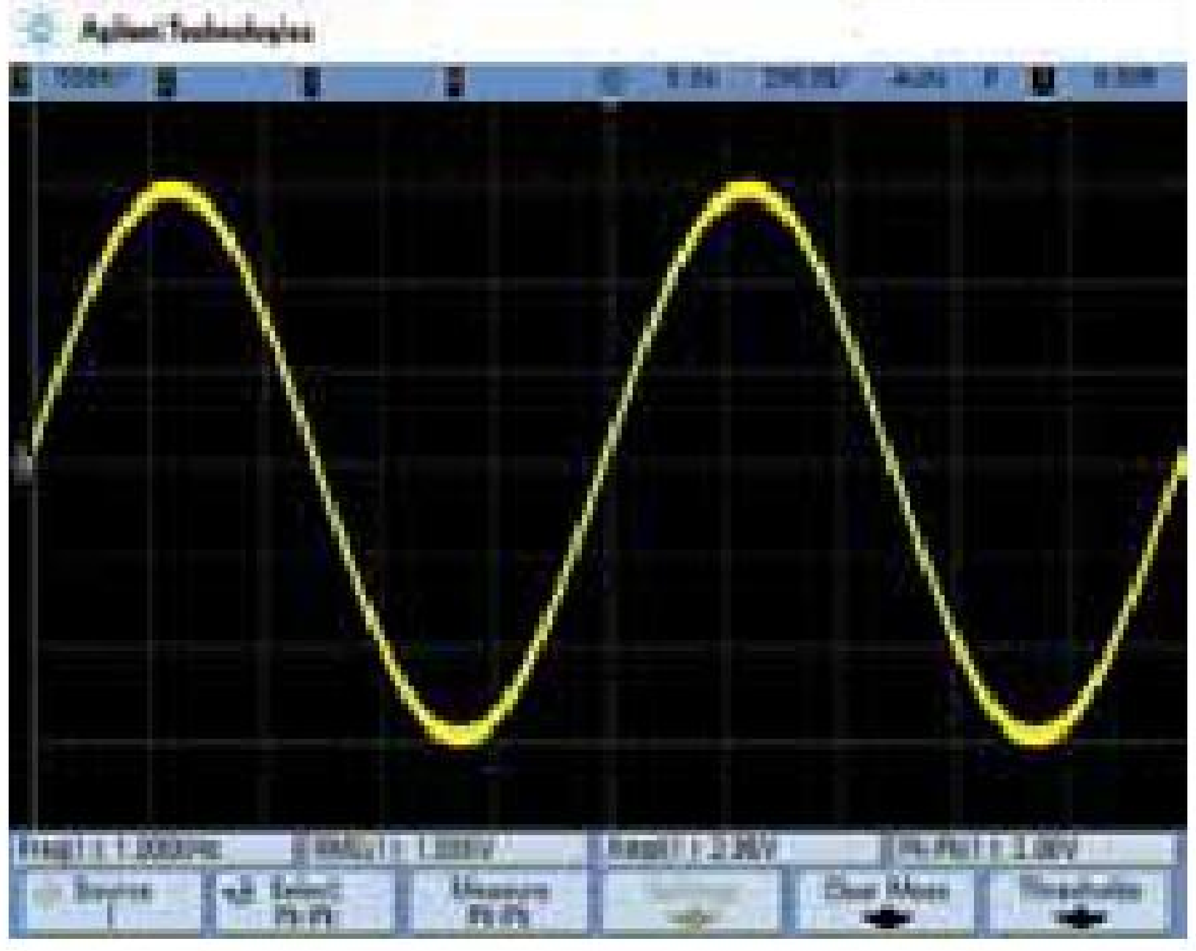


Fig.8: this screen grab shows a 1kHz sinewave from one of the analogue outputs.

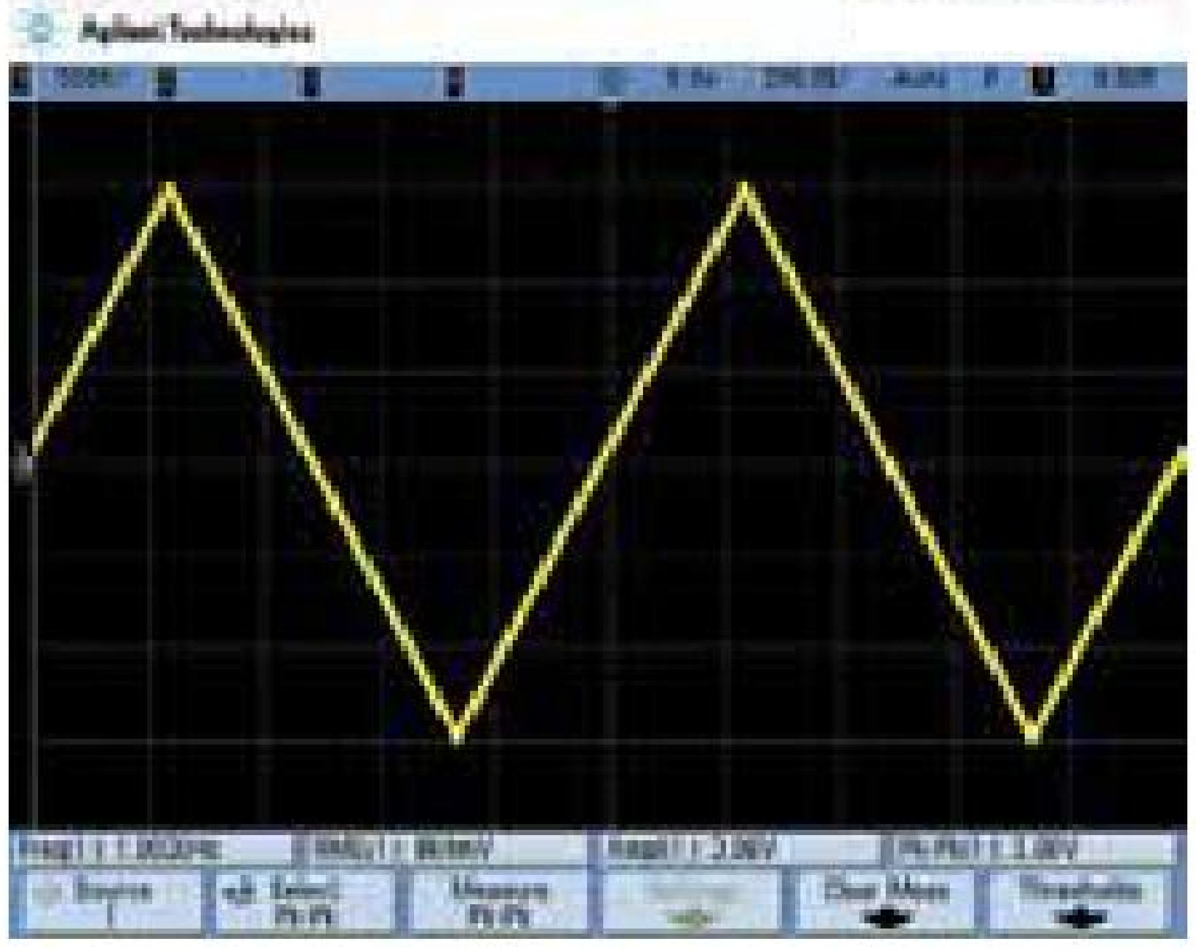


Fig.9: this is the 1kHz triangle wave output from one of the analogue outputs.

at 96kHz, we only have 40M/96k = 416 processor cycles to generate and output each data point for both channels. This may sound like plenty of cycles, but there is much to do in that time. The steps set out in Table 5 must occur for each set of four samples that are output (experimentally determined to be the optimal number).

Because this all has to be executed in under 416 cycles per sample under all circumstances (in reality slightly less), it became obvious that we needed to specialise the ISR routines for certain modes.

The final version of the software has 31 different ISR subroutines. Each one covers some subset of the 100 possible mode combinations. Some handle a single mode, others several.

The more complex the mode combination, the more specialised the ISR must be to run fast enough. It's a balancing act between having few enough routines to fit in Flash memory, but specialising them sufficiently to run fast enough.

As an example of a mode-specific ISR, there is one specifically to handle a high-to-low frequency geometric sweep with a sinewave format at the 48kHz sampling rate. Whenever you change the mode, the code determines which handler is appropriate and installs it.

Table 4: Waveform generation mode details

Locked Mode

Options: Frequency (Hz), phase difference between channels (0-360°), left channel amplitude, right channel amplitude.

Output: Each channel generates a waveform of the same type and frequency, with independent amplitudes. The phase difference between the channels is maintained at the specified number of degrees.

Uses: As well as general signal generation duty, especially when you want both channels to provide identical signals (ie, set phase difference to 0°), this could be used (for example) to test the power delivery capability of a bridged stereo amplifier, by feeding the same sinewave to its two inputs 180° out of phase.

Independent Mode

Options: Left channel frequency (Hz), right channel frequency (Hz), left channel amplitude, right channel amplitude.

Output: Each channel generates a waveform of the same type, with independent amplitudes and frequencies. There is no fixed phase relationship between the channels, although if one frequency is an integer multiple of the other, then the generator will attempt to keep them in phase (eg, 1kHz and 2kHz).

Uses: Could be used, for example, to measure high-frequency feed-through between channels, or as two independent simple signal generators.

Mixed Mode

Options: Frequency A (Hz), frequency B (Hz), amplitude A, amplitude B.

Output: Both channels generate the same waveform, although they can be independently muted. The output consists of the average of the two waves specified. There is no fixed phase relationship between the waves, although if one frequency is an integer multiple of the other, the generator will attempt to keep them in phase. Because they are averaged, the maximum amplitude of either of the two waves is effectively half that of the other modes.

Uses: Could be used to measure intermodulation distortion with the correct analysis equipment (eg, FFT analyser) or alternatively, used when you need a repetitive waveform with some harmonics.

Pulsed Mode

Options: Frequency (Hz), on amplitude, off amplitude, on time (0-999ms), off time (0-9999ms).

Output: Both channels generate the same signal, but can be independently muted. The output consists of the specified waveform and frequency, with a varying amplitude. The scale is set to the 'on amplitude' for the period of 'on time', then it changes to the 'off amplitude' for the period of 'off time'. This process repeats forever. Both amplitude changes occur on the first available zero crossing to prevent glitches in the output unless the frequency is so low as to make it impractical (<500Hz, lower in some modes).

Uses: Primarily to measure 'headroom' or 'music power' of an amplifier, but there are other situations where a pulsed waveform may be useful.

Sweep Mode

Options: Start frequency (Hz), finish frequency (Hz), sweep time (0-99.9s), off time (0-99s), amplitude.

Output: Both channels generate the same signal, although they can be independently muted. The signal consists of the specified waveform and amplitude, with the frequency sweeping between the specified start and end points. If the start frequency is set lower than the finish frequency then it will sweep up, otherwise it will sweep down. By default, the sweep rate is exponential, which means that the time it takes for the frequency to double (or halve) is consistent. However, if for some reason you want the sweep to have a constant rate of frequency change (in Hz) you can enable the 'linear sweep' mode.

Uses: Frequency response measurements for analogue equipment and speakers, speaker crossover and placement optimisation and sub-woofer matching.

Table 5: Real-time processing steps

1) Enter ISR
2) Save register context
3) For each of the four samples:
    (a) Calculate the next waveform point value
    (b) Scale it to the appropriate amplitude
    (c) If mixing, calculate the other waveforms and average them
    (d) If outputting S/PDIF, perform S/PDIF bitstream encoding
    (e) If analogue outputs are active, place sampling value in DAC buffer
    (f) Update the waveform position
    (g) Determine whether we are in a special mode (pulsed or sweep)
    (h) Adjust amplitudes/frequencies over time as necessary
    (i) Write to DMA buffer.
4) Clear interrupt flag
5) Restore register context
6) Leave ISR

Sinewave generation is the slowest of all the waveforms. Because it takes too long to calculate the sine values from first principles, we use a 6000-entry, quarter-sine table stored in the flash memory. This takes up approximately 18KB of the available 64KB.

Normally, tables stored in Flash on a dsPIC device take up 50% greater space than you would expect, because of the way it packs 16-bit data words into the 24-bit flash. However, we came up with a way to use all 24 bits of each instruction word to store the sine table data.

The possibility of packed Flash storage for data is mentioned in the Microchip documentation, but they do not explain how to do it. In the end, we had to 'pretend' the sine values were instruction op-codes and use the TBLRDL and TBLRDH assembly instructions to access them.

The remaining subroutines in the software are straightforward, if somewhat complex. The main loop scans to see whether any buttons are pressed and uses some logic to determine what any given button does, depending on the current screen. It then instructs the LCD to update and, if necessary, changes the waveform generation settings. All the while, the waveform generation code is running as needed to keep the DMA buffers full.

S/PDIF output

The S/PDIF output code is a little tricky. The S/PDIF bi-phase serial stream encodes 64 bits per sample, so for 96kHz the bit rate is 96,000 × 64 = 6.144Mbits/second. Logically, the easiest way to generate this stream is with some kind of serial output peripheral, such as SPI. However, the bi-phase (aka NRZI) encoding complicates matters.

Rather than adding external bi-phase encoding hardware, we decided the best approach was to double the serial bit rate and do the bi-phase encoding in software. This makes the maximum bit rate 12.288MHz. Fortunately, this is within the capabilities of the Data Conversion Interface (DCI) unit in the dsPIC33. However, the maximum clock rate it is able to generate internally is the master clock divided by four, ie, 10MHz.

The solution is to generate the clock externally and use the DCI in slave mode. The 12.288MHz clock signal from the 74HC393 (IC3) is fed into the DCI and this determines the rate at which data is read out of RAM via DMA and streamed to the DCI data output.

In order to make the software bi-phase encoding fast, a 256-entry, 16-bit look-up table is used. This allows us to take eight bits of data and with a single RAM lookup and conditional bit inversion, compute the bi-phase encoded bit sequence.

Then there's the issue of the logical bitstream generation, ie, coming up with the S/PDIF data stream itself. It involves combining the audio sampling data with some status bits. We generate a table of these bits when the mode is set and feed them into the logical stream as it's generated to save time.

What's coming

That's all for this month. Next month, we'll show you how to build the two boards and install them in the case.

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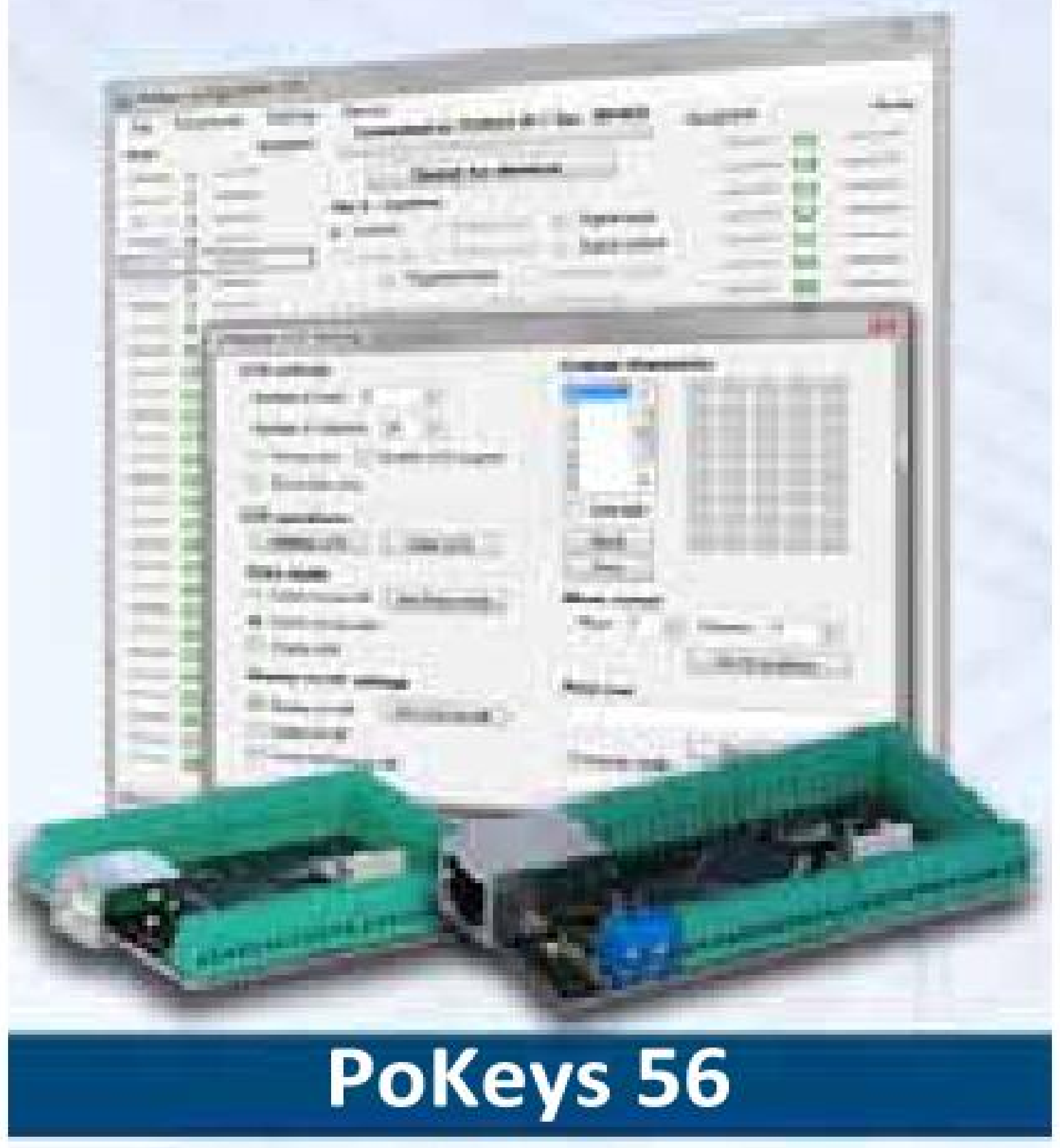

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TechnoTalk

From Brown To Green

Mark Nelson

Our lead story is best not read at the meal table, not that this bothers our tasteless reporter, Mark. Applied electronics can now turn sewage into money (but don't try this at home!).

A **TOTAL** lack of taste is something I am noted for, which is doubtless why I grossed out on the schlock horror film *Toxic Avenger* from Troma Studios. But in the non-fantasy world, toxic sludge is not so funny. Biosolids, the residual, semi-solid material remaining from industrial wastewater or sewage treatment processes, are an inevitable and putrid by-product from human existence.

What makes this far worse are contaminants that are not broken down in the treatment process, such as heavy metals (arsenic, cadmium, copper, for instance), and toxic chemicals (eg, plasticisers and residues from clinical medicines). Together this makes toxic sludge, a potent source of danger to human life.

One way of 'losing' biosolids is burning them with coal in coal-fired power stations, but this is hardly a green option and the toxic heavy metal elements remain. A novel proposition comes from Israeli start-up company Global Recycling Projects Ltd, which transforms toxic sludge into energy. As Israel National News reports, unlike other green projects (such as electric cars) that produce environmentally sound results, but still involve a large carbon footprint in the energy they depend upon, GRPL's scheme has the distinction of being truly green.

Biomass reactor

It manages this by harnessing energy from the sun to power a solar biomass reactor that turns the sludge into fuel gas for powering turbines to generate electricity. A field of tracking mirrors directs concentrated solar radiation towards the facility, powering the biomass reactor. With this system, waste processors can get rid of their sludge efficiently and easily, possibly selling the electricity to local utilities.

To avoid human contact with toxic sludge, the firm has developed a robot that is remotely controlled and has explosion-proofing to protect the workforce. This can pump up to 200 cubic metres of sludge per hour, while the solar-powered pyrolysis reactor produces fuel gas and solid 'char' material similar to charcoal.

Although our sunshine levels would not enable this plant to work in Britain, it's ideal for Israel, where this new technology is being deployed for large companies and municipalities at several locations. As GRPL boss Boaz Zadik says, 'Sludge is everywhere and we are working to make sure it disappears into electricity.'

Switch to LED

Last week, I was pleased to see that my local Tesco supermarket had begun to stock LED replacements for standard light bulbs. Less satisfying was the price, just shy of £20 (which appears to be the going rate for LED bulbs that are more than decorations).

On the Amazon website you can buy 'real' bayonet-cap LED bulbs for as little as £6.33, but these are paltry 5W affairs, equivalent to an incandescent lamp of just 25W. They are made by Philips Lighting, which, as it happens, called in December for a rapid switch worldwide to LED lighting.

At the UN *Climate Change Conference* in Durban, the company's senior director for energy and climate change stated that the world has now reached the tipping point where LED lighting can now be used for general high-quality lighting in almost all applications. Making the switch would help combat climate change, save energy and improve people's lives, he argued.

According to the International Energy Agency, lighting accounts for 19 per cent of global electricity production and a complete switch to the latest energy-efficient LED lighting globally could save energy consumption for lighting by 40 per cent. It won't take off while bulbs remain priced at twenty quid a pop, but a concerted move would bring rapid price falls, with the side benefit of removing from our ceilings those dreadful CFL bulbs that still take 60 seconds or more to reach useful brightness.

Serious about saving?

I guess we all want to be seen as green, but how many of us walk the walk, as well as talking the talk? I'm certainly guilty of leaving my laptop battery on constant charge, but now I have discovered an energy-saving product that guarantees to recover its cost within 18 months.

What makes the Eliminata Laptop Saver different is its truly novel *modus operandi*. Although the unit is about the same size as a common timer plug, it is not just a time switch. Inside it is a microprocessor that continuously manages the laptop plugged into it.

You don't need to remember to do anything, the unit will deliver savings completely automatically. It does this by monitoring the laptop's battery charge level, switching the appliance off or on in the same way as you could with the wall switch at the electrical socket. The voltage and current going to the laptop are not changed in any way when it is switched on, so it cannot harm your computer.

Even when a laptop battery is fully charged and the laptop is either off or in stand-by mode, energy is still taken from the mains by the laptop's own power supply and power management circuits. This energy is wasted and also shortens the life of the battery.

The Laptop Saver measures the mains current drawn (and hence the laptop battery's charge level), disconnecting power when it is fully charged. Afterwards, power is briefly reconnected at regular intervals to allow it to check the battery's charge state. If the battery needs more charge – for example if the laptop has been used – power remains connected until it is fully charged again. Wasted energy is typically reduced by a factor of 60 and battery lifetime could, it is claimed, be extended by a year.

Entirely new

Obvious though this may sound, until now there has been no product like this available. Others on the market require you to switch the appliance off and on manually, using a remote control, but this task is easily forgotten or else the remote goes missing.

Released this spring, the Laptop Saver will cost you £23, and the manufacturer calculates it will save you £13 a year if your laptop is not in use 18 hours per weekday, and 44 hours each weekend (full calculations on their website at: **www.eliminata.com/product-laptop.html**). Eliminata products are made by the British firm Energy Reducing Products Ltd, based deep in Silicon Fen at Landbeach, near Cambridge. Further energy saving products will be produced later this year, including smart wall sockets that monitor and memorise the use pattern of appliances.

Very, Very Accurate Thermomete

Based on the very accurate Dallas DS18B20 digital temperature sensor, this LCD Thermometer/Thermostat provides accurate readings to one decimal point. The LCD shows current, minimum and maximum temperature readings.

An internal buzzer will sound when temperature limits are exceeded. It is intended for controlling air conditioners, heaters, cool rooms or wine cellars. The software is user-customisable.

LCD Thermometer / Thermostat
UP
MENU
DOWN
TEMP NOW 30.6°C
TEMP MAX 32.5°C

Design by Michael Dedman (Altronics)
Words by Michael Dedman and Nicholas Vinen

r/Thermostat

THIS digital thermometer/thermostat is designed to be easy to use, accurate and stable for a variety of applications. With an overall range of –55°C to +125°C, it can read and display temperature with a great deal of precision – 0.5°C over most of its range – as well as trigger a warning buzzer or external devices if the temperature goes outside a specified range.

Circuit details

The full circuit diagram for the LCD Thermometer/Thermostat is shown in Fig.1. The heart of the device is the Atmel ATTiny861 microcontroller, which has 8KB of program flash, can run up to 20MHz and is specified for use in commercial and industrial applications.

The very accurate Dallas/Maxim DS18B20 is the temperature sensor. It has its own inbuilt analogue-to-digital converter (ADC) and one-wire digital communication module, allowing it to transmit the real temperature in digital format directly to the microcontroller. This results in more stable and accurate readings than many purely analogue temperature sensors, as well as removing the need for any kind of biasing circuitry to allow sensing of temperatures below 0°C.

Features

- Measures temperatures from –55°C to +125°C
- 0.5°C accuracy from –10°C to +85°C
- Sensor can be up to 300m away from controller
- Two relays with NO or NC contacts for switching devices
- Buzzer alert for over and under-temperature
- Adjustable hysteresis to prevent output oscillation
- Runs from 8V to 35V DC @ 120mA

As a result, the specifications are outstanding. They include, accuracy of ±0.5°C from –10°C to +85°C and a full range of –55°C to +125°C. The minimum and maximum temperature thresholds can be specified in 0.1°C increments. You can decide whether the piezoelectric buzzer should sound if the temperature reading goes above the maximum threshold, below the minimum or both.

On-board, there are two miniature relays, with normally open (NO) and normally closed (NC) contacts, which are available for triggering external devices under either or both conditions. The software also allows you to adjust the hysteresis, which eliminates 'relay chatter' from occurring during switching.

We have reports that it is possible to mount the sensor up to 300m away from the control box without affecting the performance, although the furthest Altronics has tested it is 100m. If you are planning on a cable run more than a few tens of metres, you may find it necessary to replace the 4.7kΩ pull-up resistor on the sensor signal line with a lower value, due to the increased capacitance of a longer cable.

There is also an in-circuit programming header on the PC board. The ATTiny861 comes pre-programmed, so there is no requirement for you to use it. However, more advanced constructors may wish to modify the microcontroller program to suit their own requirements.

You can do this by using the BASCOM compiler for Atmel microprocessors (available from **www.mcselectronics.com**). An Atmel programmer will also be required to write new code to the ATTiny861's Flash memory. Depending upon the pin configuration of your programmer, you may also need to make an adapter to suit the programming header on the PC board.

The tiny (TO-92 size) Dallas/Maxim DS18B20 temperature sensor (shown here about twice life size with heatshrink insulation) gives this thermometer its accuracy and wide measurement range.

Flexibility

Unlike many commercial products, this project provides separate relays for the upper and lower temperature thresholds, and provides normally open and normally closed contacts to give maximum flexibility. You can even hook up a heater to one relay and a cooler to the other, if necessary.

Keep in mind the limited voltage and current ratings of the relays (0.5A @ 125V AC, or 1A @ 24V DC). So, if you want to switch a mains device or provide more current, the simplest way is to use the thermostat's internal relays to drive 250V AC-rated external relays. You can use the same voltage supply for the thermostat to drive the external relay(s), say 12V or 24V DC.

Applications

Designer Mike Dedman was so enthused with the features of this device he built two. One is interfaced to his home aquarium heater, and this holds the water temperature at 25±1°C.

The second is interfaced to his car air conditioning system. Most cars have no real temperature control in air conditioning mode, and as a result, the compressor cycles on and off continuously until the windscreen freezes up. Thanks to its adjustable temperature limits, this project can, for example, keep a car's interior at a comfortable 21±0.5°C.

It achieves this by switching on the compressor until the interior temperature gets down to 21°C, then the air conditioning turns off and remains off until it goes above 21.5°C (ie, a temperature rise of 0.5°C). Not only is this a great deal more comfortable for passengers, but it also improves the fuel economy of the car.

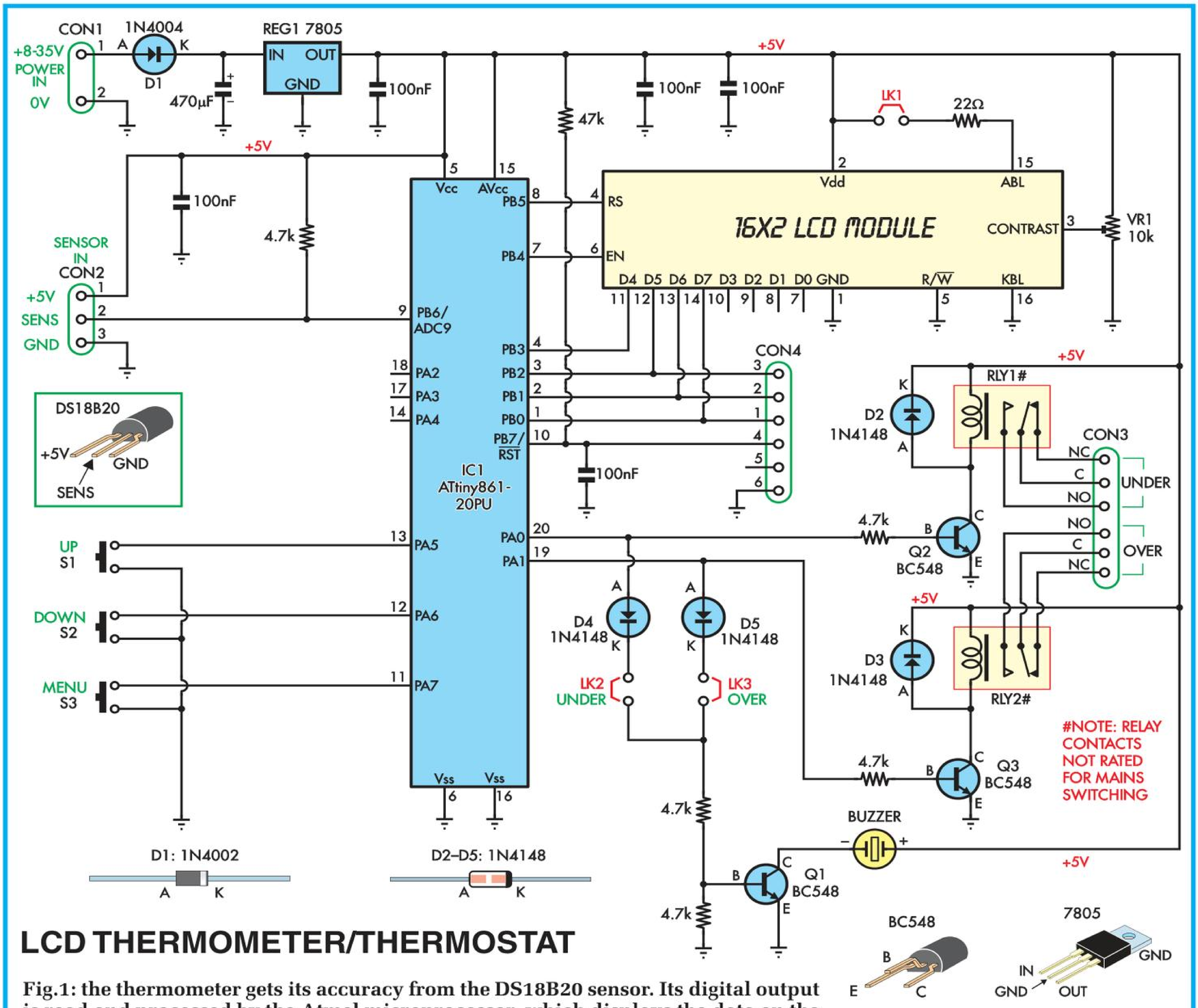
These are just two of the practical uses that this unit can be used for. Other uses – we're sure you'll think of many more – include wine cellars, cool rooms, home-brew setups, fan heaters and fan coolers.

Construction

The component overlay of the PC board assembly is shown in Fig.2, with the LCD module piggy-backed on the main board. This board is available from the *EPE PCB Service*, code 840.

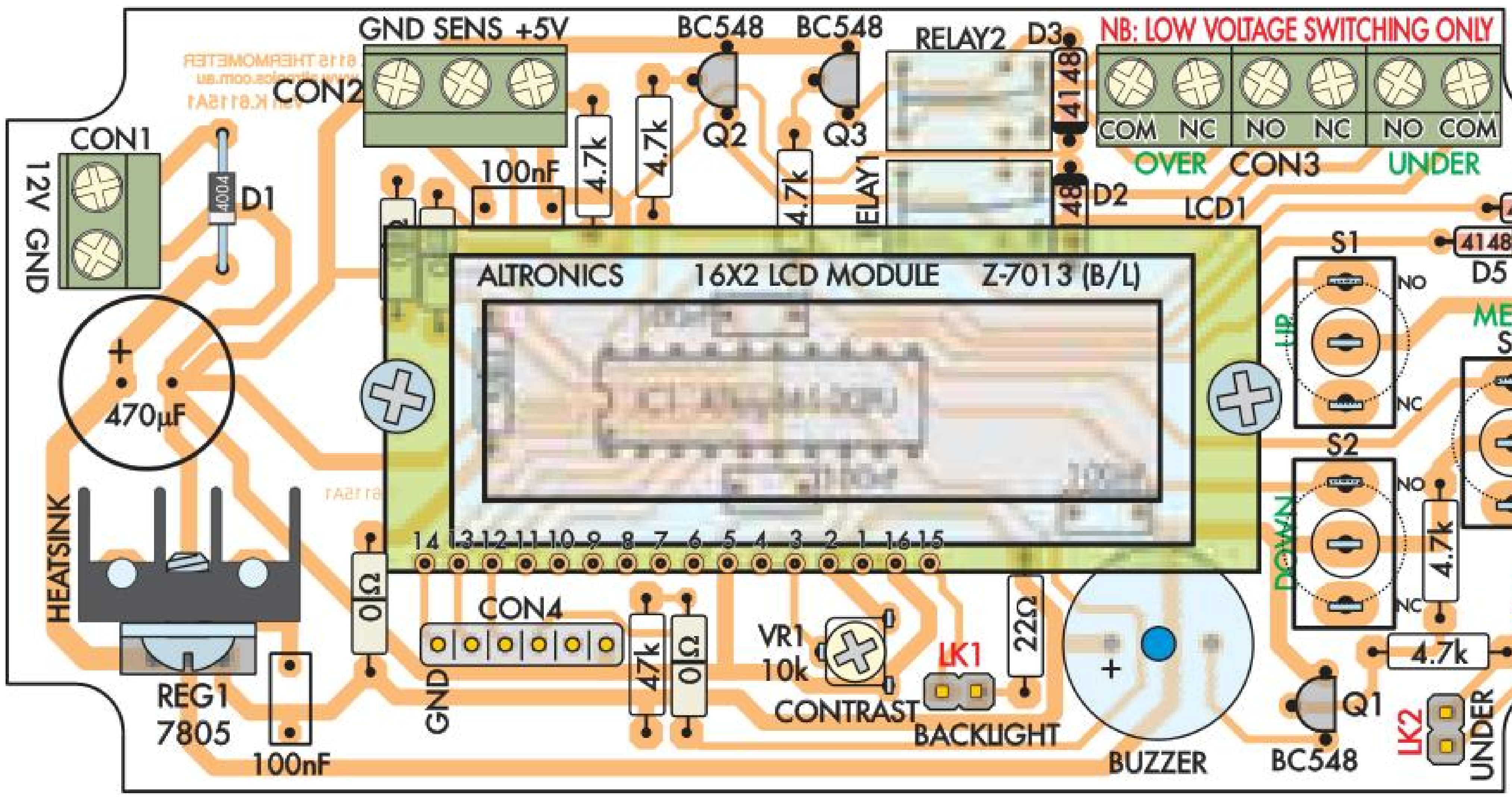
Start by checking the copper tracks on the board for short circuits or fractures/over etching, and then check the components against the parts list for completeness. Note that the microcontroller and sensor come packed in anti-static foam – it is best to keep them that way until it is time to install them.

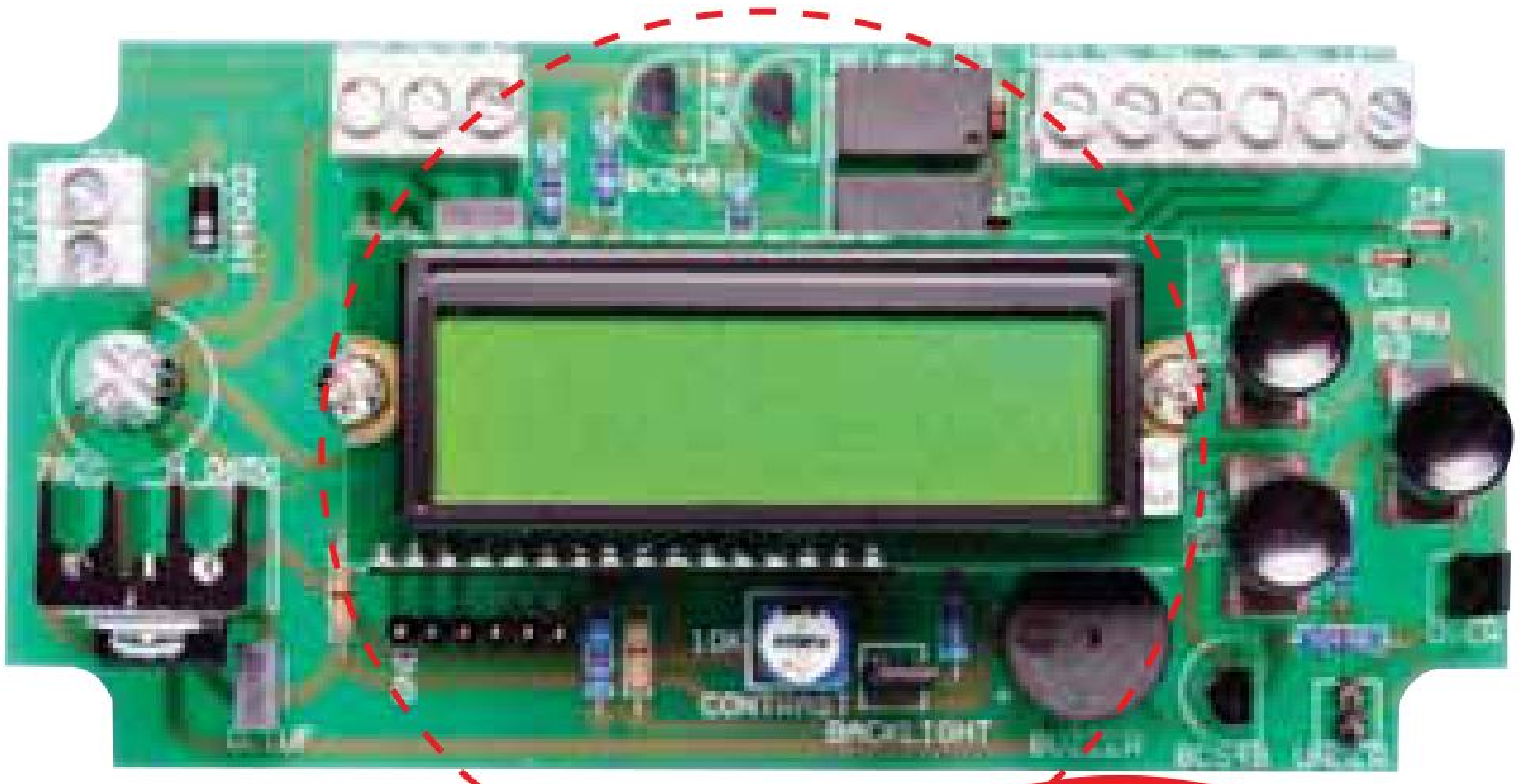
Once you are sure the board has no faults, install the resistors and diodes. Measure each resistor's value with a multimeter before installing it – the colour bands can be hard to read.


CON1
1N4004
REG1 7805
+8-35V POWER IN
0V
A
K
D1
470µF
IN OUT
GND
100nF
+5V
47k
100nF
100nF
LK1
22Ω
Vdd
ABL
16X2 LCD MODULE
CONTRAST
VR1 10k
RS
EN
D4 D5 D6 D7 D3 D2 D1 D0 GND
R/W
KBL
Vcc
AVcc
PB5
PB4
PB3
PB2
PB1
PB0
PB7/RST
PB6/ADC9
PA2
PA3
PA4
PA5
PA6
PA7
PA0
PA1
Vss
Vss
IC1 ATtiny861-20PU
4.7k
SENSOR IN
CON2
+5V
SENS
GND
DS18B20
+5V
GND
SENS
CON4
RLY1#
D2 1N4148
CON3
NC
C
NO
UNDER
OVER
Q2 BC548
D3 1N4148
RLY2#
Q3 BC548
4.7k
UP S1
DOWN S2
MENU S3
D4 1N4148
D5 1N4148
LK2 UNDER
LK3 OVER
BUZZER
Q1 BC548
#NOTE: RELAY CONTACTS NOT RATED FOR MAINS SWITCHING
D1: 1N4002
D2–D5: 1N4148
BC548
B
E
C
7805
IN
GND
OUT

LCD THERMOMETER/THERMOSTAT

Fig.1: the thermometer gets its accuracy from the DS18B20 sensor. Its digital output is read and processed by the Atmel microprocessor, which displays the data on the LCD module and also controls the alarm/control circuitry.





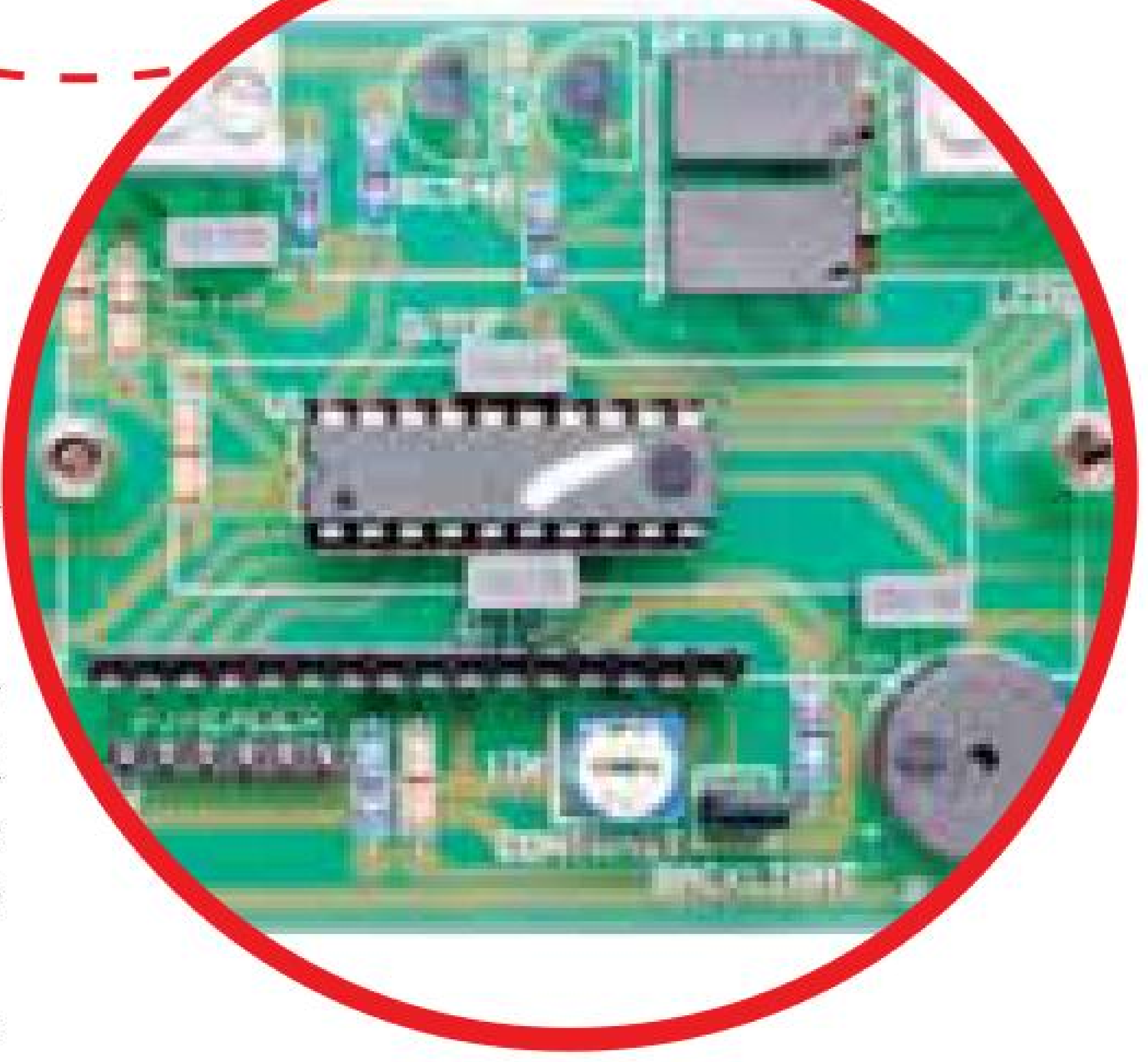


Fig.2 (top): the component overlay, shown here with the LCD module in place and the components underneath it ghosted. This is also shown in the same-size photographs above and right – the area of the red circle at right, without the LCD module in place, is that shown within the dashed circle above.

Be careful with the diode polarities – check that they are oriented as shown on Fig.2, the PC board component overlay. Be sure to install the 1N4002/1N4004 diode in the location shown, near the power supply input – the rest of the diodes are the smaller 1N4148s.

Next, solder in the 20-pin DIL socket for the microcontroller, which goes in the middle of the PC board. Make sure the notch at the end of the socket lines up with the one drawn on the component layout diagram, Fig.2, and ensure it is sitting flat on the board before soldering all the pins. Don't install the IC yet.

After that, install the buzzer and potentiometer VR1. The buzzer is polarised; it can fit in either way, but only one is correct. Make sure the '+' shown on the sticker or plastic case is facing the '+' shown on the PC board overlay, before soldering it.

Once it's in place, you can pull the sticker off. The trimpot is easier; it will only go in one way.

Pin headers

Follow with the male pin headers. There is one 6-pin header and three 2-pin headers. Snap off an appropriate length from the strip provided using pliers and solder them into place.

This is also a good time to install the 16-pin female header, but first you have to cut it to size. The supplied header has a few too many pins. The easiest way to cut it is with a pair of side cutters – find the 17th pin socket and carefully make a cut in the middle of that pin (ie, not between the 16th and 17th pins, otherwise pin 16 may fall out). Double check before making the cut that there are going to be 16 intact pins left afterwards.

Now it's just a matter of tidying up the remaining bits of plastic left over from where you made the cut, and you can then solder it into place on the PC board. It must be mounted flat on the PC board, and parallel with the LCD outline shown in Fig.2, before soldering all the pins – otherwise, you will have trouble fitting the LCD later.

Transistors

Now you can install the three TO-92 package transistors – all are BC548s. Don't mix the temperature sensor up with the transistors (they are all TO-92 packages). If you accidentally solder the sensor onto the board instead, not only is it going to be difficult to remove, but it could be damaged.

The pins of the BC548s are too close to fit through the holes on the PC board, so use needle-nose pliers to splay the two outer pins forward and outward (with the labelled side of the transistor at the front) and the middle pin backward. Then bend them all back parallel so that they fit through the holes, and solder them in place. The flat face of each transistor is oriented as shown on the overlay.

Next, install the five non-polarised MKT capacitors. Two of the capacitors sit right up against the IC socket, but there should be just enough space on either side for them to fit.

Having done that, solder the two relays to the board. They can only go one way around – don't bend the pins, and ensure they are sitting flat before soldering them down.

Now fit the sole electrolytic capacitor (470μF) into place. Ensure the longer leg goes into the hole adjacent to the '+' symbol on the component overlay. After soldering it, install the three

Part List – LCD Thermometer/Thermostat

1 PC board, code 840, available from the *EPE PCB Service*, size 60mm × 122mm
1 UB3-size box with screened and punched front panel
1 TO-220 heatsink, 10 × 22mm (Altronics H0640)
5 M3 × 6mm pan-head screws
1 12-way screw terminal block, PC-mount (5.08mm pitch)
1 40-way male pin header strip (2.54mm pitch)
1 20-way female pin header strip (2.54mm pitch)
3 Tactile pushbutton switches
2 Mini 1A SPDT relay, 5V coil (Altronics S4111)
1 Self-oscillating piezoelectric buzzer, 3V to 16V, PC-mount
1 20-pin DIL IC socket
1 Silicone rubber TO-220 washer
2 M3 × 15mm tapped steel spacers
2 Header pin shorting blocks
30cm length of 10-wire ribbon cable
10cm length of 3mm heatshrink tubing

Semiconductors
1 ATTiny861-20PU (pre-programmed by Altronics) (IC1)
1 DS18B20 digital temperature sensor
1 16x2 alphanumeric LCD module, with backlight (Altronics Z7013)
1 7805 5V positive voltage regulator (REG1)
3 BC548 *NPN* small-signal transistors (Q1 to Q3)
1 1N4004 diode (D1)
4 1N4148 signal diodes (D2 to D5)

Capacitors
1 470µF 16V electrolytic
5 100nF 50V MKT polyester

Resistors (0.25W 1%)
1 47kΩ   5 4.7kΩ   1 22Ω   5 0Ω (or wire links)
1 10kΩ horizontal trimpot

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terminal blocks – 2-way, 3-way and 6-way – into the appropriate locations, ensuring that the wire entry points face to the outside of the PC board.

Regulator

The 7805 regulator should be loosely fitted to its heatsink before soldering it to the PC board. Insert an M3 × 6mm bolt through the metal tab of the 7805 regulator. Place a TO-220 silicone washer behind the TO-220 tab, with the bolt passing through the hole. Now screw the regulator and washer onto the heatsink. Don't tighten it completely though – just screw it in most of the way.

Having done that, you can now put the regulator legs into the holes on the PC board and, lining up the two posts on the heatsink with the holes in the PC board at the same time, push the regulator/heatsink assembly until it's right up against the PC board.

Now turn the PC board over and solder the heatsink down. You will need a hot iron, because the heatsink will draw a lot of the heat away. Make sure after you've soldered the first post that the heatsink is fully in contact with the PC board surface before attaching the second.

Check that the silicone washer is sitting properly behind the regulator – adjust it if it isn't – and holding it in place, tighten the bolt down. Now the TO-220 package should be held rigidly in place and you can solder its pins to the board and trim the excess.

At this point, it's also worth bolting the two tapped spacers to the PC board. They go on the same side as the rest of the components. Make sure the M3 bolts are tightened right up.

Installing the switches

Installation of the pushbutton switches is a little tricky because they need to sit about 2mm off the PC board in order to project properly through the holes in the case lid.

Since they do not sit up against the PC board, you will have to adjust their angle so that they are properly centered with respect to those holes.

First, take one of the switches and check its correct orientation on the PC board. The component overlay, Fig.2, shows the 'NO' and 'NC' ends of each button, and this is also stamped into the metal shield on the side of the specified switches.

You will need to check the stamped information to make sure you are orienting them correctly. Once that is done, insert one of the switches through the holes, but not all the way. With its body about 2mm above the PC board, solder the centre pin, trying to keep it as close to vertical with respect to the PC board as possible.

Putting it in the box

Assembly is basically complete, so you can now install the PC board in the box – first, check it is at the right height and properly centered.

The PC board is held in the box by a 'shelf' or notches cut into the ridges molded into the inside surface (there are no mounting screws as such).

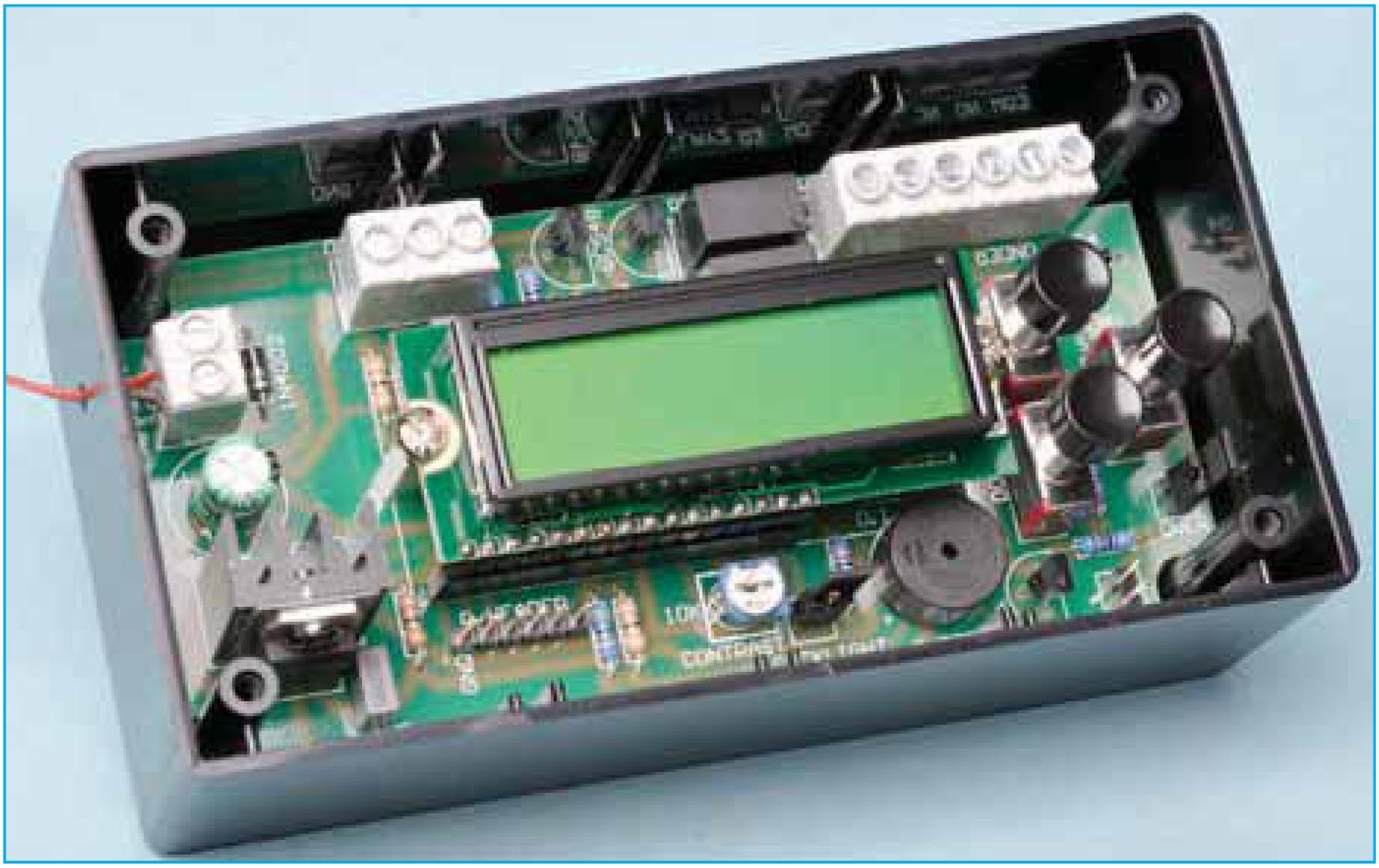
Hold the PC board with the component side up and the terminal blocks away from you, and tilt the far side upwards. Now lower it into the box until the edge closest to you engages the notches. Then rotate it by pushing the back down until it snaps into place.

It's possible (though unlikely) that, due to manufacturing tolerances, it won't quite fit properly. If this is the case then use a file to slightly reduce one or both sides of the PC board until it fits in place.

If the sides of the box bow outwards with the PC board in place, take it out and file off a small amount from the edges. The easiest way to check this is to rest the lid on top of the box with the PC board inside and check that the edges line up properly. If they do, then there is no problem.

Otherwise, file away the PC board until it fits better.

Now place the lid down on top of the box, but don't attach the screws. This should allow you to determine whether you have to adjust the switch button, and if so, in which direction for it to project properly through the appropriate hole in the lid.



Here's how it all goes together in the UB3-size box, ready for the lid to go on. Watch the power polarity – if it's wrong, it won't work. The connections to the temperature sensor must also be right – if they're wrong, you will probably destroy it.

The surface of the switch push-buttons should stick up slightly through the lid so that you can press them easily, without projecting more than a millimeter or two above it.

Once you have determined how much you need to adjust the push-button, remove the lid and lever the PC board out of the box by grabbing the six-way terminal block and pulling it up and away from the box edge.

With the board out, re-melt the solder joint holding the switch in place and carefully nudge it in the appropriate direction. Then re-install the PC board and repeat this procedure until you are happy with the placement. Then solder the two remaining pins.

Once that is finished you will need to go through the same steps for the other two switches.

Installing the microcontroller

The microcontroller (IC1) sits under the LCD, so it must be installed first. However, before you do that, it's a good idea to check that what you have built so far is working correctly.

To do so, wire an ammeter (or a multimeter on, say, its 500mA range) in series with a suitable power supply (12V is a good choice) and connect it to the power input terminal block with a couple of lengths of wire.

Switch on the power supply and note the current drawn. It should be less than 20mA. Now check the voltage across pin 5 and pin 6 of the microcontroller DIL socket. It should be close to 5V – if it is not, disconnect power and check for incorrectly installed components.

If (and only if) all is OK, (with power still disconnected) insert the microcontroller IC in its socket. Bend its pins so that they fit in the socket and push it down firmly. Make sure you don't put it in backwards – the notch at the end of the IC package must line up with the one on the socket.

Soldering the LCD

Like the pushbutton switches, the LCD module is also a little tricky to solder due to physical mounting requirements. The easiest way to do it is to snap off a length of 16 pins from the remaining male pin header strip and, keeping the longer part of the pins facing down, loosely push it down into the female header you've already soldered to the PC board.

Now place the LCD down on top of the spacers so that the header pins fit through the row of holes on the LCD module and bolt it down to the tapped spacers using the remaining M3 × 6mm bolts. By the way, don't remove the plastic protecting the LCD screen yet.

Once the LCD is bolted down and can't move, use a small flat-bladed screwdriver to push the male header up or down so that the tips of the pins stick up a tiny bit through the LCD module. They should only be about half a millimetre above the LCD module board surface. That way, the other end of the pins will be properly engaged to the female header.

Ensure that it is sitting parallel with the LCD, so that the same amount of pin sticks up at both ends. Now carefully, without moving the header, solder it to the LCD module from the top.

Testing and set-up

To properly test the thermometer, you need to wire up the temperature sensor. Your final installation may require a different arrangement, but for now, the easiest thing to do is to use a length of ribbon cable.

Strip off three wires from the ribbon cable and pull the wires apart until there are single strands 4cm long at one end and 8cm at the other. Strip and tin about 5mm of conductor from all three wires at both ends.

Cut three equal lengths of the thin heatshrink tubing – slightly longer than the legs on the temperature sensor. One at a time, slip a length of heatshrink onto one of the 8cm-long wires and push it down as far as you can. The tinned end of the wire should be sufficiently clear of the heatshrink tubing so that when you solder it, it won't shrink prematurely. Repeat for all three pins.

Slide the heatshrink up over the pins and solder joints and shrink it. This should leave no exposed metal that could short the pins together.

You may want to shrink a short length of 6mm diameter heatshrink tube over the sensor, pins and ends of the wire, as we have shown in our photos. This way, the whole sensor is electrically insulated and the pins can't be bent or move easily.

Now you can screw the other end of the ribbon cable into the three-way terminal block on the PC board, making sure that the three wires connect to their correct terminals, as shown on the circuit diagram (Fig.1 – CON2). If you get them mixed up it could damage the sensor.

It's alive!

Reapply power and check that the thermometer is functioning properly. Check that current draw is below 100mA. If all seems OK, adjust the contrast potentiometer (VR1) with a small Philips screwdriver until text is visible on the display.

The top line should show the current temperature reading, while the bottom line alternates between the minimum and maximum values that have been seen during the current session. Pick up the temperature sensor between two fingers and check that the temperature rises as your body heats it. When you let go, it should slowly fall back to the ambient temperature.

Preparing the case

Before you can finish the set-up and installation it's necessary to drill some holes in the sides or rear of the case for the power supply wiring, temperature sensor cable and, if necessary, cables for connection to the relay(s).

As you can see in the photos, we have drilled one small hole for the power wires and one for the sensor cable, but you can vary this pattern according to your needs. Multicore cable with a circular cross-section is probably the best choice for a permanent installation. If you drill the holes just big enough to feed it through, you can get a fairly tight seal so that dirt and dust can't get in.

Setting the jumpers

Before putting the lid on the box, you need to set the three links or jumpers (labelled LK1, LK2 and LK3). If you want to change them later you will have to remove the lid.

Placing a shorting block on LK3 (labelled 'OVER') will make the buzzer sound whenever the sensed temperature goes over the upper threshold. The limit can be changed any time, but the jumper can't be changed as easily.

Similarly, LK2 (labelled 'UNDER') will, if shorted, cause the buzzer to sound if the sensed temperature is below the lower threshold.

The third link, LK1, is labelled 'BACKLIGHT' and not surprisingly, if shorted will enable the LCD backlight. Unless low current consumption is critical, this is probably a good idea, since it makes the LCD text more easily visible, especially in dim light.

The majority of applications will not require LK2 and LK3 shorted at the same time, so you will probably only need two shorting blocks. If you need more, they are readily available (eg, from old computer motherboards).

Finishing off

To finish off, feed the cables through the holes drilled in the case. Pull them through far enough that you can screw the wire ends into the terminal blocks on the PC board. Make sure that no loose strands of wire emerge from the terminal blocks to short their neighbours.

Once all wires are firmly attached you can snap the PC board into place. This may require pulling the cables partially back through the holes in the case.

You can now remove the protective plastic film from the LCD and place the lid on top of the box, making sure that the push-buttons move freely in their holes. Secure the lid in place using four self-tapping screws.

Where from, how much?

This project was designed and developed by Altronics Distributors Pty Ltd, who retain the copyright on the design, the microprocessor code and PC board artwork.

Complete kits (as per the parts list on page 28) are available from Altronics (www.altronics.com.au) for about £40 (plus P&P).

Final set up and use

To adjust the settings, press the 'menu' button. The display should now read 'MIN TRIGGER' at the top, and the bottom line should indicate the current lower temperature threshold. This is the temperature which will trigger Relay 1 if the sensed temperature falls below it, and set off the 'UNDER' alarm if you have enabled it.

Press the up and down buttons to adjust it – each press will change the value by 0.1°C.

Now press the 'menu' button again and the display should show 'MAX TRIGGER', which is the temperature which will trigger Relay 2 if the sensed temperature rises above it, and set off the 'OVER' alarm if you have enabled it. MAX TRIGGER is adjusted in the same way as MIN TRIGGER.

Press the 'menu' button a third time, the top line will read 'HYSTERESIS'. This determines how often the device you are controlling with the thermostat will switch, by setting the amount by which the temperature has to change after the thermostat switches, for it to switch again.

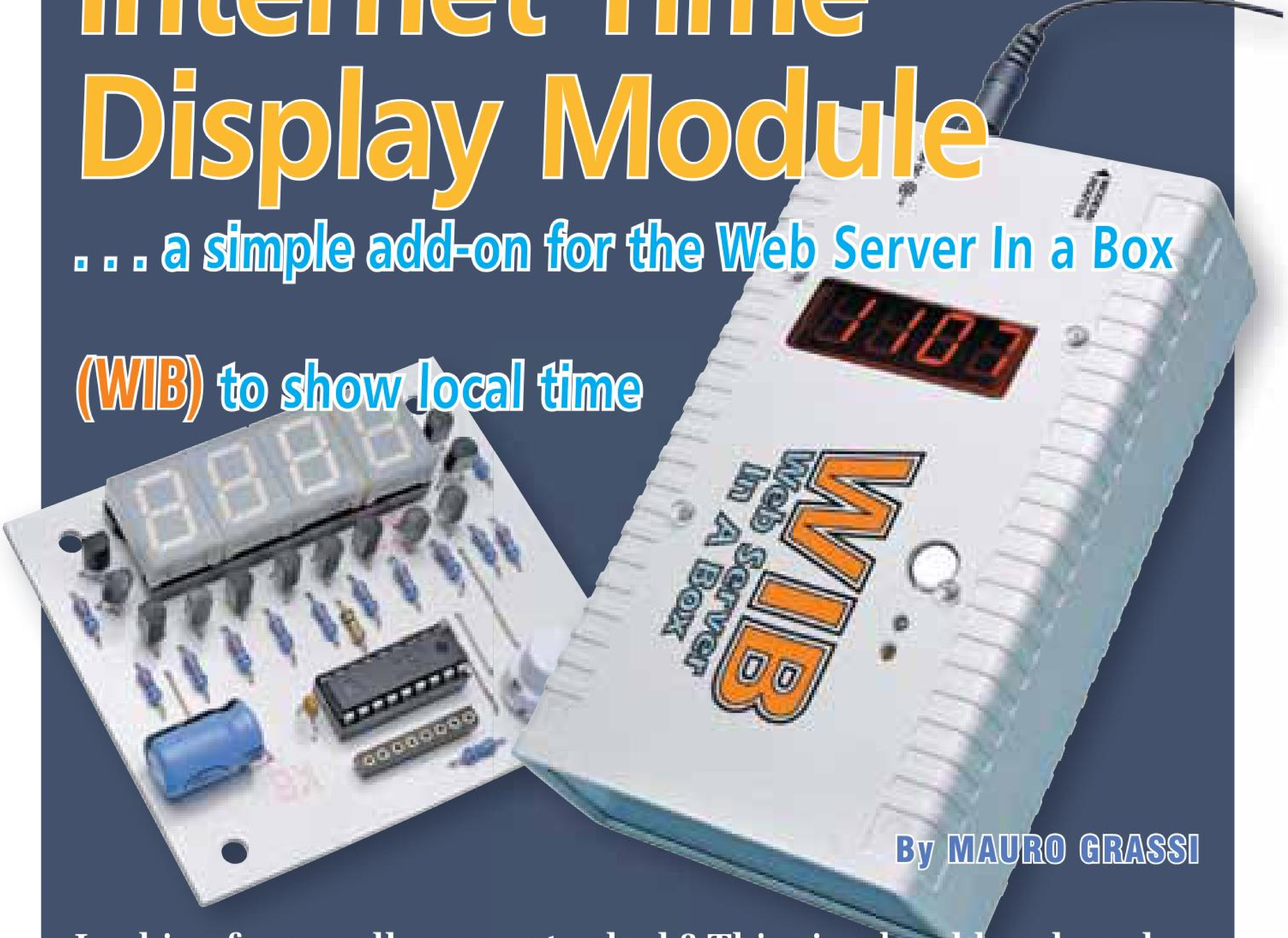
For example, if you set the upper threshold temperature to 25°C and the hysteresis value to 0.5°C, then Relay 1 will switch on as soon as the temperature exceeds 25°C, but won't switch off until it falls below 24.5°C. The same is true of the lower threshold, but in reverse. This prevents rapid switching of the relay due to the feedback loop formed by your heater/cooler.

A larger hysteresis value will cause the heater/cooler to switch less often, but also means the temperature will vary over a wider range.

Once set, press the 'menu' button again and the default display should reappear. The thermometer/thermostat will operate normally again and the new values, stored permanently in EEPROM memory, will take effect. ***EPE***

Internet Time Display Module

. . . a simple add-on for the Web Server In a Box (WIB) to show local time



By MAURO GRASSI

Looking for a really accurate clock? This simple add-on board for the WIB (Web Server In A Box) displays the time and date, as gathered from an internet time server. You can use it as a clock you never need to adjust, and it can even be configured in the WIB to automatically adjust for daylight saving time.

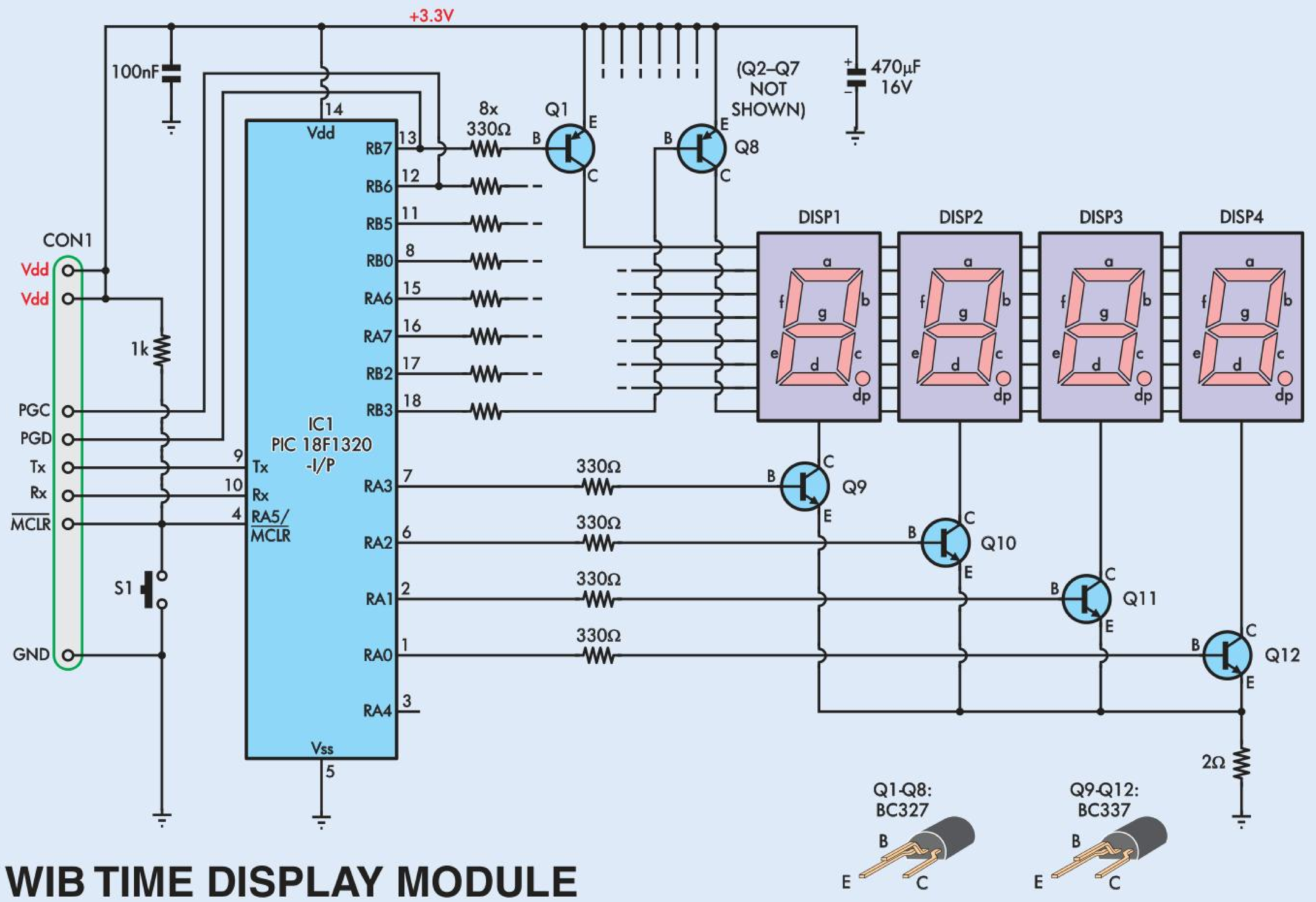
IN THE previous three issues of *EPE*, we published the *WIB (Web Server In a Box)*, an ethernet-based web server with a memory card. This simple add-on board allows the time and date to be displayed on a 7-segment four-digit LED display. The time is gathered from the Internet, and is re-synchronised every 10 minutes by the WIB for update on the display.

In operation, the time and date information gathered by the WIB is sent to the add-on module via the on-board serial port. The hours, minutes, seconds, day, month and year can all be displayed. A single pushbutton switch allows you to scroll through the time and date readings, or you can set the unit to automatically scroll through the time and date displays.

Circuit operation

Take a look at the WIB Time Display Module circuit diagram of Fig.1. It's based on a single microcontroller (IC1), in this case a PIC18F1320. Apart from that, there's just the four 7-segment LED displays, 12 transistors to drive the displays and a handful of minor parts.

To keep the cost down, an 8MHz *RC* oscillator internal to IC1 is used as the system clock. Its accuracy is quite sufficient for our purposes – it really only affects the baud rate of the UART (universal asynchronous receiver/transmitter) used to receive the time and date



WIB TIME DISPLAY MODULE

Fig.1: the circuit uses microcontroller IC1 to process the serial data from the WIB PC board. IC1 then drives four 7-segment LED displays in multiplex fashion via switching transistors Q1 to Q12.

information from the WIB. In any case, the baud rate is synchronised automatically to the baud rate of the UART in the WIB (more on this later).

In operation, IC1 receives the time and date information on its Rx pin (pin 10). This data is then processed by the internal firmware and IC1 then drives the 7-segment LED displays (DISP1 to DSP4) in multiplex fashion via switching transistors Q1 to Q12.

The 7-segment LED displays each have a common cathode; these are driven (one at a time) by the RA3 to RA0 outputs of IC1 via *NPN* transistors Q9 to Q12. A single 2Ω resistor is used to limit the peak current through the displays. This needs to be substantial to obtain reasonable brightness.

The 330Ω resistors provide base-current limiting for the transistors.

By contrast, the corresponding anodes of each display digit are connected together and these are driven by IC1 via *PNP* transistors Q1 to Q8. Transistors Q1 to Q7 drive the segments, while Q8 drives the decimal point.

Switch S1 is used to scroll between the time and date displays and to select the display mode. Normally, pin 4 (RA5/$\overline{\text{MCLR}}$) of IC1 is pulled high via a 1kΩ resistor, but each time S1 is pressed, pin 4 is pulled low.

A short press, ie, less than 1s, scrolls to the next display, while a long press (longer than 1s) is used to change the display mode. This is described in greater detail later.

Power for the circuit is derived from the +3.3V rail on the WIB board, and is fed via connector CON1. A 470µF electrolytic capacitor and a 100nF monolithic capacitor provide supply decoupling for the module.

The PGC, PGD and $\overline{\text{MCLR}}$ lines are used only for programming the PIC microcontroller, if necessary. These inputs are all made available on CON1, as are the power supply and receive (Rx) connections. A transmit output from the microcontroller has also been made available, but is unused in this application.

Software

All software program files for the *WIB Time Display Module* are

WIB Time Display Module: Main Features

- Displays local time and date derived from an internet time server
- Can be configured in the WIB to automatically adjust to daylight saving time
- Six different display modes for time and date (including static and scrolling displays)
- Three line interface to the WIB, with automatic baud rate adjustment
- Persistent settings (settings stored in EEPROM)

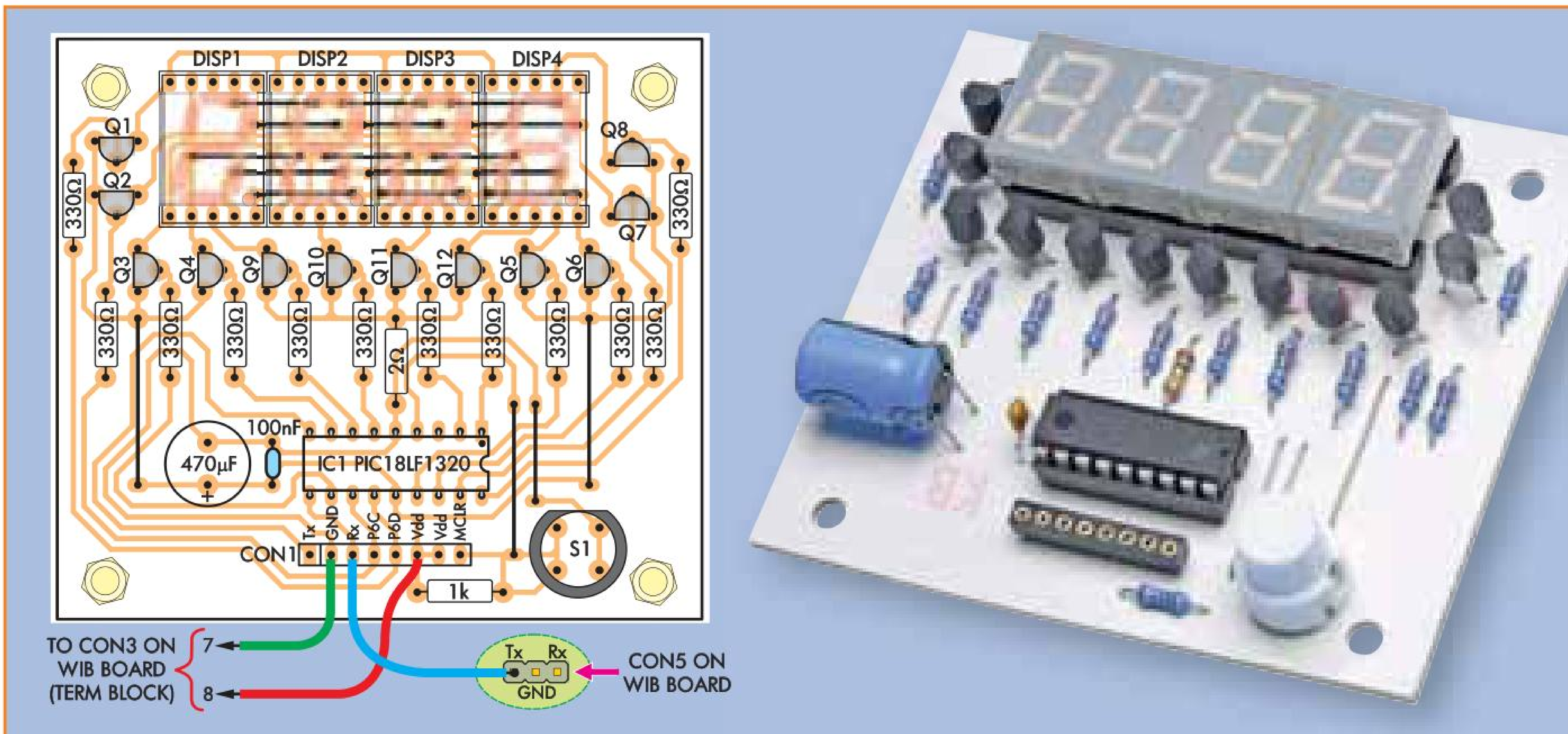


Fig.2: all the parts are assembled on a single PC board measuring 76mm × 69mm. Take care with the orientation of switch S1 and the microcontroller, and be sure to use the correct transistor type at each location.

Parts List

- 1 PC board, code 836, available from the *EPE PCB Service*, size 76mm × 69mm
- 1 piece of red perspex, 51mm × 18mm
- 4 M3 × 25mm nylon screws
- 4 M3 × 12mm nylon spacers
- 4 M3 nylon nuts
- 1 18-pin IC socket
- 2 20-pin IC socket strips or 1 × 40-pin IC socket (to be cut in half)
- 1 SPST PC-mount momentary switch (Jaycar SP-0721)
- 1 0.5m-length of 0.7mm tinned copper wire (for links)

Semiconductors
- 1 PIC18F1320-I/P programmed microcontroller (IC1)
- 8 BC327 *PNP* transistors (Q1 to Q8)
- 4 BC337 *NPN* transistors (Q9 to Q12)
- 4 7-segment red common cathode LED displays (Jaycar ZD-1855)

Capacitors
- 1 470μF 16V radial electrolytic
- 1 100nF monolithic

Resistors (0.25W, 1%)
- 1 1kΩ
- 1 2Ω
- 12 330Ω

available from the *EPE* website at: **www.epemag.com**.

Firmware overview

The firmware scans the pushbutton switch (S1), debounces it and differentiates between a short and a long press. It also listens for activity on the serial port.

In operation, the time and date are sent by the WIB (when the time module is enabled) as a packet of bytes. Note that the time module in the WIB must be enabled via the SNTP set-up page, as shown in Fig.5 (ie, in the default website supplied with the WIB).

The baud rate is gathered automatically from a synchronisation header in the packet. This means that the module will work with any serial port baud rate of between 600 and 115,200 bps (although even higher speeds will work).

When the firmware receives a packet, it will display it according to the currently set display mode. There are seven display modes in total, as outlined under 'Display modes' on the final page, and switch S1 is used to select between them.

Note that any settings made using S1 are persistent, ie, they are stored in EEPROM and are retained if the power is switched off. These settings include the display mode, whether the time is displayed in 12 or 24-hour format, and the order in which the day and month are displayed. These are preferences that can vary according to locality (the default values are set for Australia).

Building it

The WIB Time Display Module is built on a single-sided PC board, coded 836, measuring 76mm × 69mm. This board is available from the *EPE PCB Service*.Fig.2 shows the board assembly details.

Before starting the construction, you should inspect the board for defects, including shorts between copper tracks and open circuit tracks. That done, you can begin by installing the 19 wire links. Many of these go under the LED displays, so it's vital that they go in first.

You can use 0.7mm (or similar) tinned copper wire for the links. These links should all be nice and straight, so that they don't short together. If necessary, you can straighten the link wire by clamping one end in a vice and then stretching it slightly by pulling on the other end with a pair of pliers.

Once the links are in, you can move on to the resistors. There are just three different values and you should check them using a digital multimeter. Make sure that the correct value is installed at each location.

Next, the eight BC327 *PNP* transistors can be soldered in place. These are

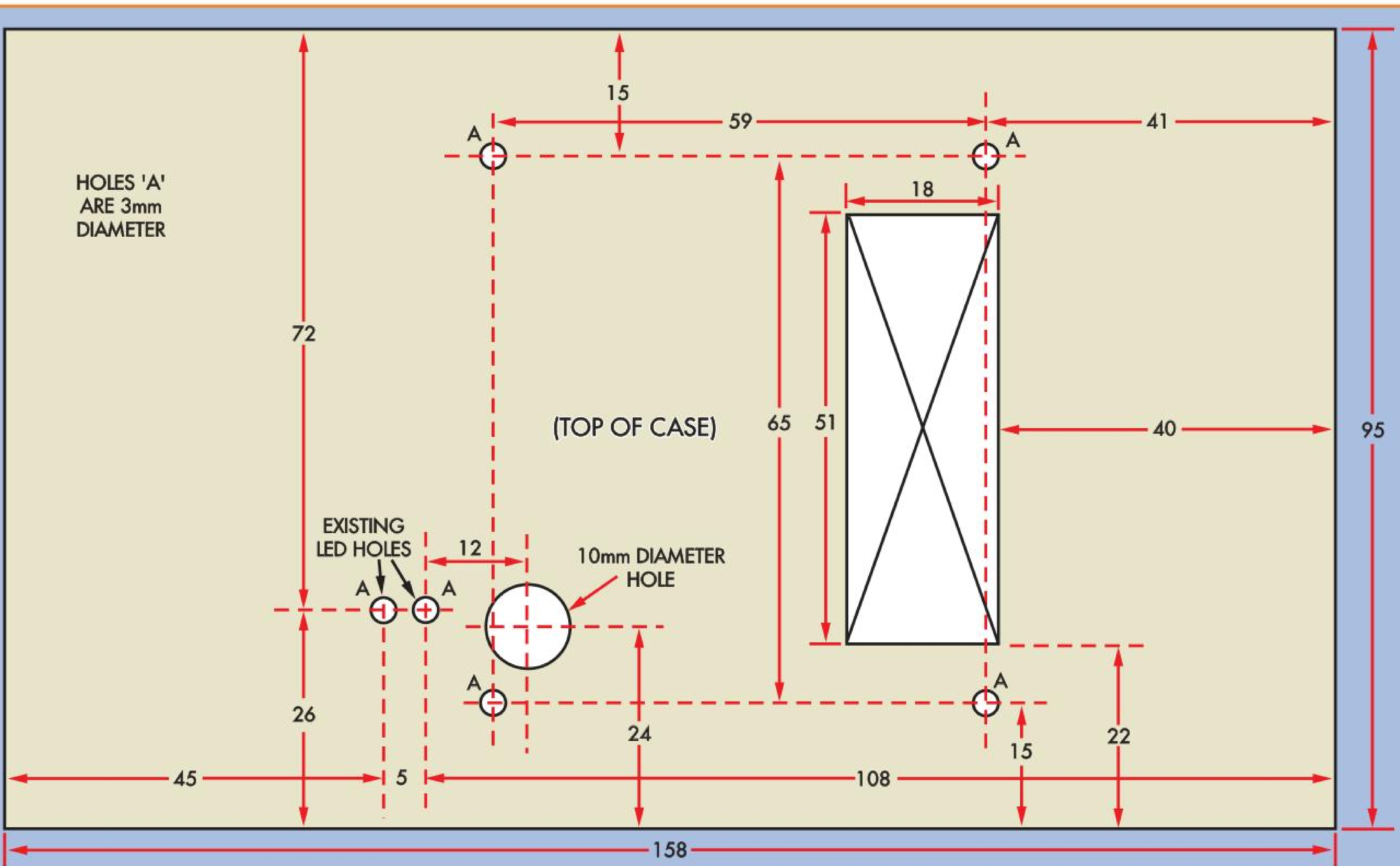


Fig.3: the drilling and cutout diagram for the lid of the case. The display cutout can be made by drilling a series of holes around the inside perimeter, then knocking out the centre piece and filing to a smooth finish.

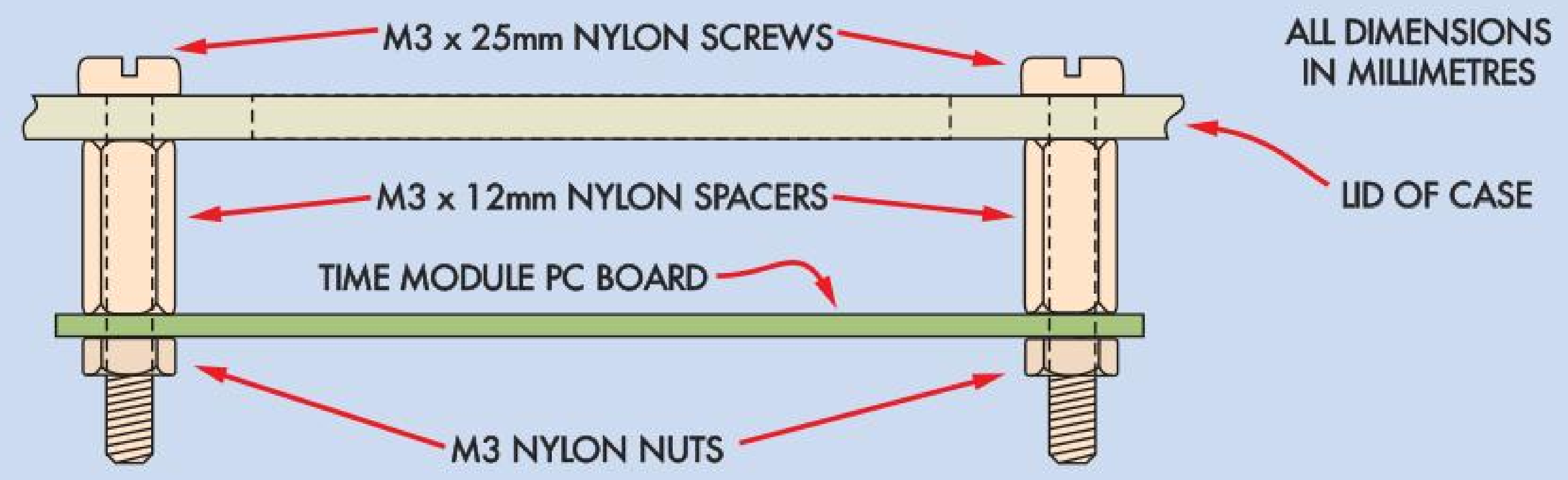


Fig.4: this cross-sectional diagram shows how the WIB Time Display Module is secured to the lid of the case. It's mounted on four M3 × 12mm nylon spacers and secured using M3 × 25mm nylon screws.

transistors Q1 to Q4 on the left and Q5 to Q8 on the right. They will only go in one way, but be sure to install them in the correct locations.

Once these are in, you can install the four BC337 *NPN* transistors. These are transistors Q9 to Q12, and they are located just below DISP2 and DISP3.

The next thing to do is solder in the socket for IC1. Note that the notch must match the component overlay shown in Fig.2.

If you are building the WIB Time Display Module from a kit, the microcontroller will be supplied pre-programmed. If not, you will need to program it with the firmware file, which can be downloaded from the *EPE* website.

Once programmed, install IC1 in its socket with the correct orientation.

Mounting the displays

The four 7-segment LED displays are mounted by plugging them into two 20-pin socket strips. You can either use SIL pin socket strips for this job, or you can cut a 40-pin IC socket into two 20-pin strips.

Once the pin strips are in, plug the four displays in, making sure their decimal points are at bottom right (see photo). Be sure to push each display down as far as it will go and make sure that all the pins go into the sockets.

Switch S1 is next on the list. It must be installed with the flat side of its body oriented as shown in Fig.2. The assembly can then be completed by installing the two capacitors and 8-way socket connector CON1. Take care with the orientation of the 470μF electrolytic capacitor.

Connecting it to the WIB

As shown in Fig.2, only three leads are required to connect the Time Display Module to the WIB PC board. The +3.3V (Vdd) and GND (ground) connection can be picked up at the screw terminal blocks, while the Rx connection must be connected to the Tx (UART transmit) output pin on CON5 of the WIB.

You can either make the connections to CON1 and CON5 by soldering the leads to the underside of the PC boards, or you can plug the leads directly into the sockets and apply a small amount of solder to secure them.

Because of the higher current consumption when the display

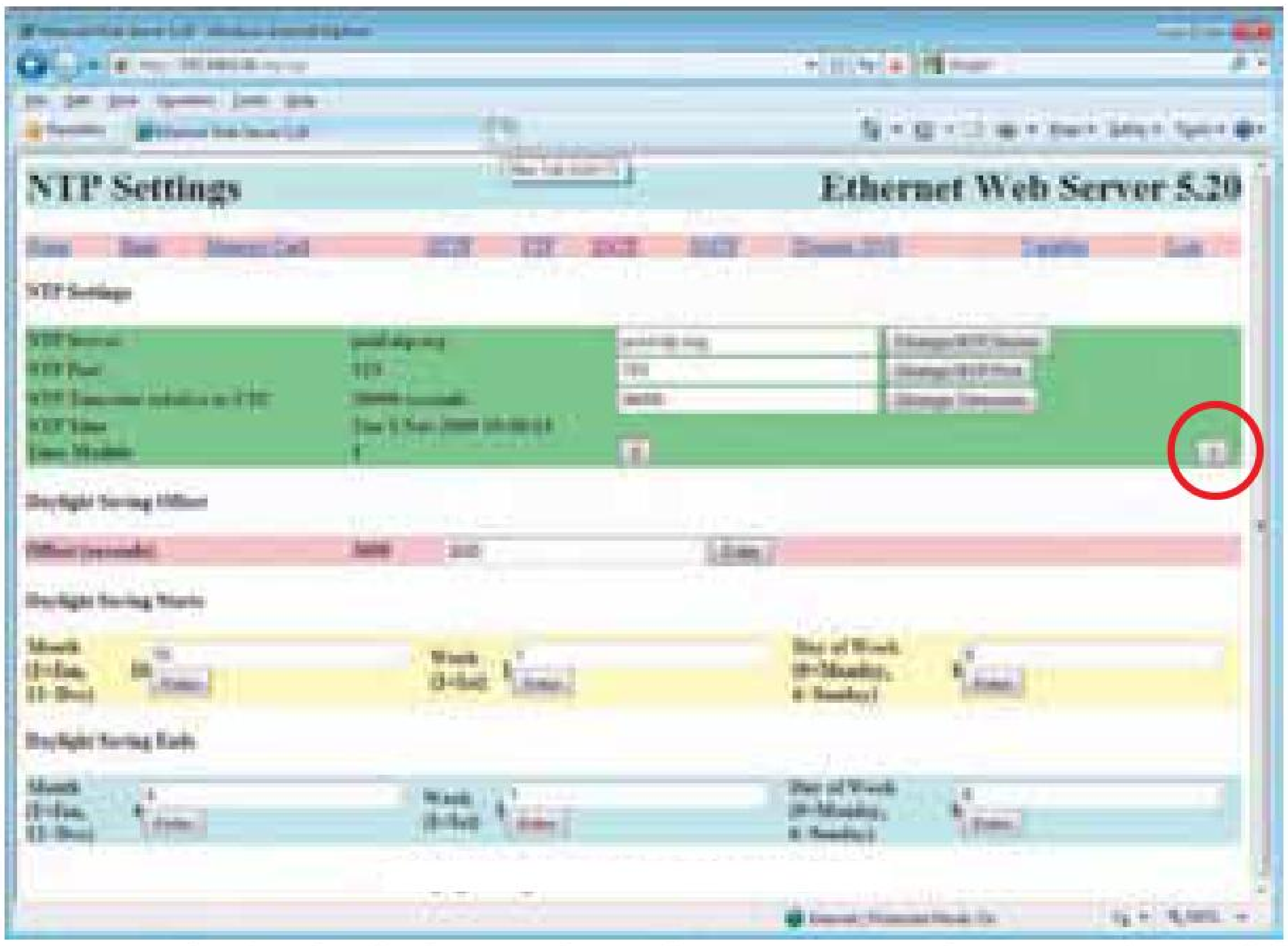


Fig.5: in order for the clock to work, you have to enter in the settings for a valid NTP server in the NTP Settings page of the default website supplied with the WIB. You also have to enable the Time Module by clicking the '1' button (circled in red).

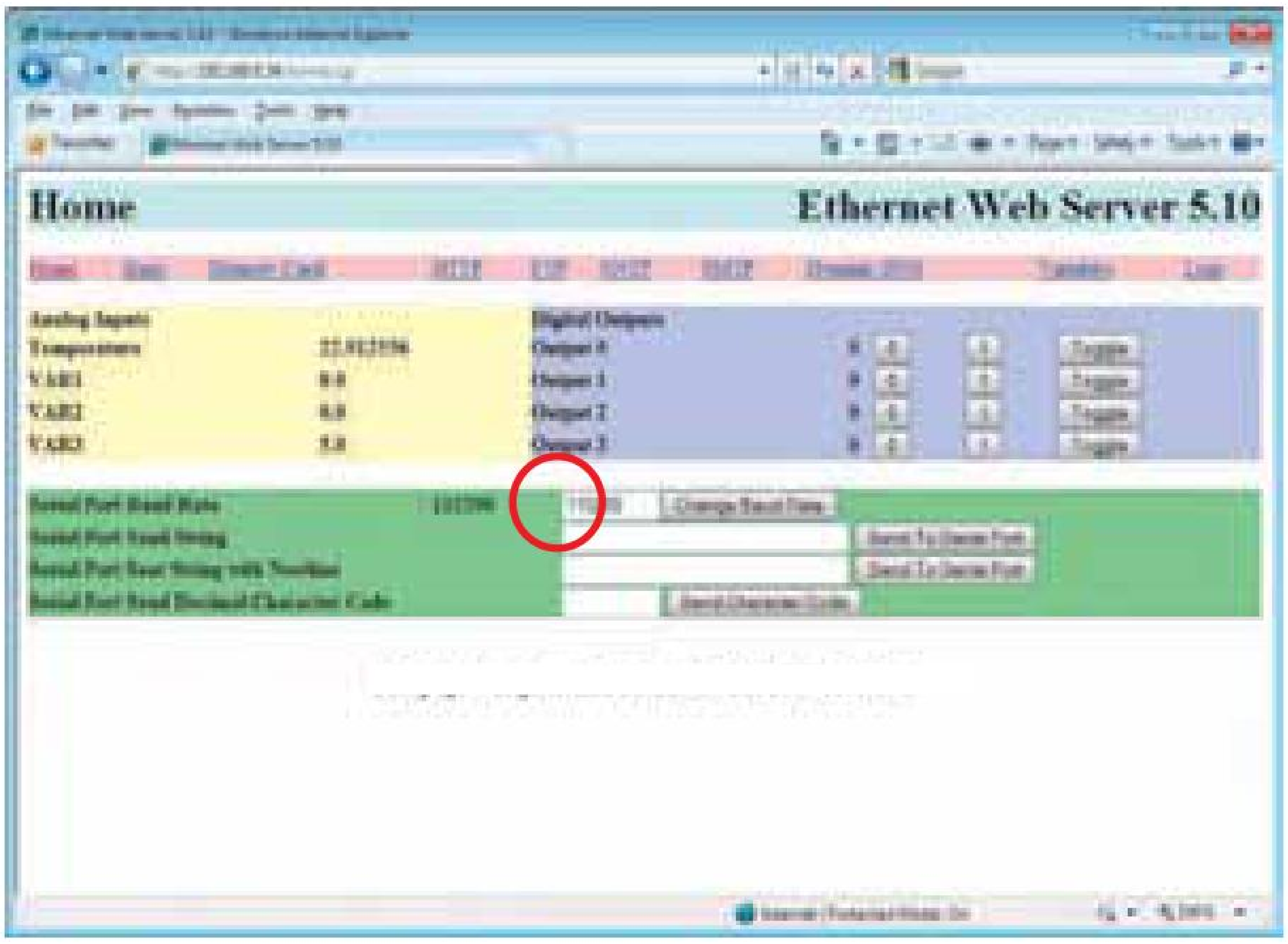


Fig.6: the default Serial Port Baud Rate of 115200 (circled) can be left as it is on the Home page of the default website. However, just about any value between 600 and 115,200bps can be used, because the display module automatically synchronises to the baud rate.

module is connected, you will need a higher-rated plugpack than the one originally specified in the December 2011 article. Back then, we specified a 6V to 9V 300mA plugpack, but you should make that a 6V to 9V 500mA plugpack if you are also using the WIB Time Display Module.

The existing regulator on the WIB board will cope with the increased current without problems, although it will run warmer.

Boxing it

The completed PC board can either be mounted in a separate case or it can be installed in the WIB case. If you choose the latter, then you will have to drill some additional holes in the lid and make a cutout for the LED displays.

Fig.3 shows the drilling details for the lid. You can make the display cutout by drilling a series of holes around the inside perimeter of the marked area, then knock out the centre piece and file the job to a smooth finish.

Once the holes have been drilled, the module can be mounted in position on four M3 x 12mm nylon spacers, and secured using M3 × 25mm nylon screws – see Fig.4. That done, test fit the two halves of the case together without the end pieces and check that there is adequate clearance between the two boards (ie, no shorts).

If everything is correct, the case can then be fully assembled and the lid secured in place using the self-tapping screws supplied. A 51mm × 18mm piece of red perspex can be pushed into the display cutout to give a good finish. A couple of dabs of epoxy adhesive on the edges will hold it in place.

The red perspex diffuses the light and makes the digits look uniform in brightness.

Auto baud rate detection

As stated previously, the firmware in the WIB Time Display Module uses automatic baud rate detection. This means that the module will work with most serial port baud rates between 600 and 115,200 bps.

Make sure, however, that the time data is being sent out by the WIB. This is done by enabling it in the SNTP window of the default website supplied with the WIB (and downloadable from the *EPE* website).

Basically, you have to enter in the settings for a valid NTP server as described on pages 32-33 of the January 2012 issue. You then have to turn on the Time Module by clicking the '1' button (circled on Fig.5).

Timeout display

In normal operation, the WIB sends out data packets containing the current time and date to the Time Display Module via the serial port. However, if the Time Display Module does not receive a packet during the timeout period (about 3s), it will change its display to four dashes and a periodically blinking decimal point.

This means that the time module does not have valid time and date data to display. This can occur when the Time Module function is disabled in the WIB.

A timeout can also occur if the UART baud rate in the WIB is suddenly changed (ie, on the home page of the supplied website). In this case, the Time Display Module will initially show the timeout display described above. However, it will then automatically adjust to the new baud rate within a matter of seconds, and again begin displaying the correct time.

Display modes

Before applying power to the unit, check the board carefully for incorrect parts placement and missed solder joints. Once you are satisfied that all is OK, apply power to the WIB and check the display. The unit should initially show the timeout display (four dashes) but should then begin displaying the correct time once the WIB has booted up and accessed an Internet time server.

The default display is 24-hour time (hours and minutes), but this can be altered, as explained below.

As stated previously, switch S1 is used to change the display readings and the mode of operation. The circuit responds to two types of button presses – a short press of less than 1s, and a long press of greater than 1s.

A short press always takes you to the next display reading, ie, from hours and minutes to minutes and seconds and then to the day and month, and then to the year and so on.

Let’s take a closer look at the different display reading and modes:

Mode 1: time in either 24-hour or 12-hour mode, consisting of the hour and minutes, with a decimal point between them blinking at 2Hz.

Mode 2: time in minutes and seconds format, with a decimal point blinking at 1Hz.

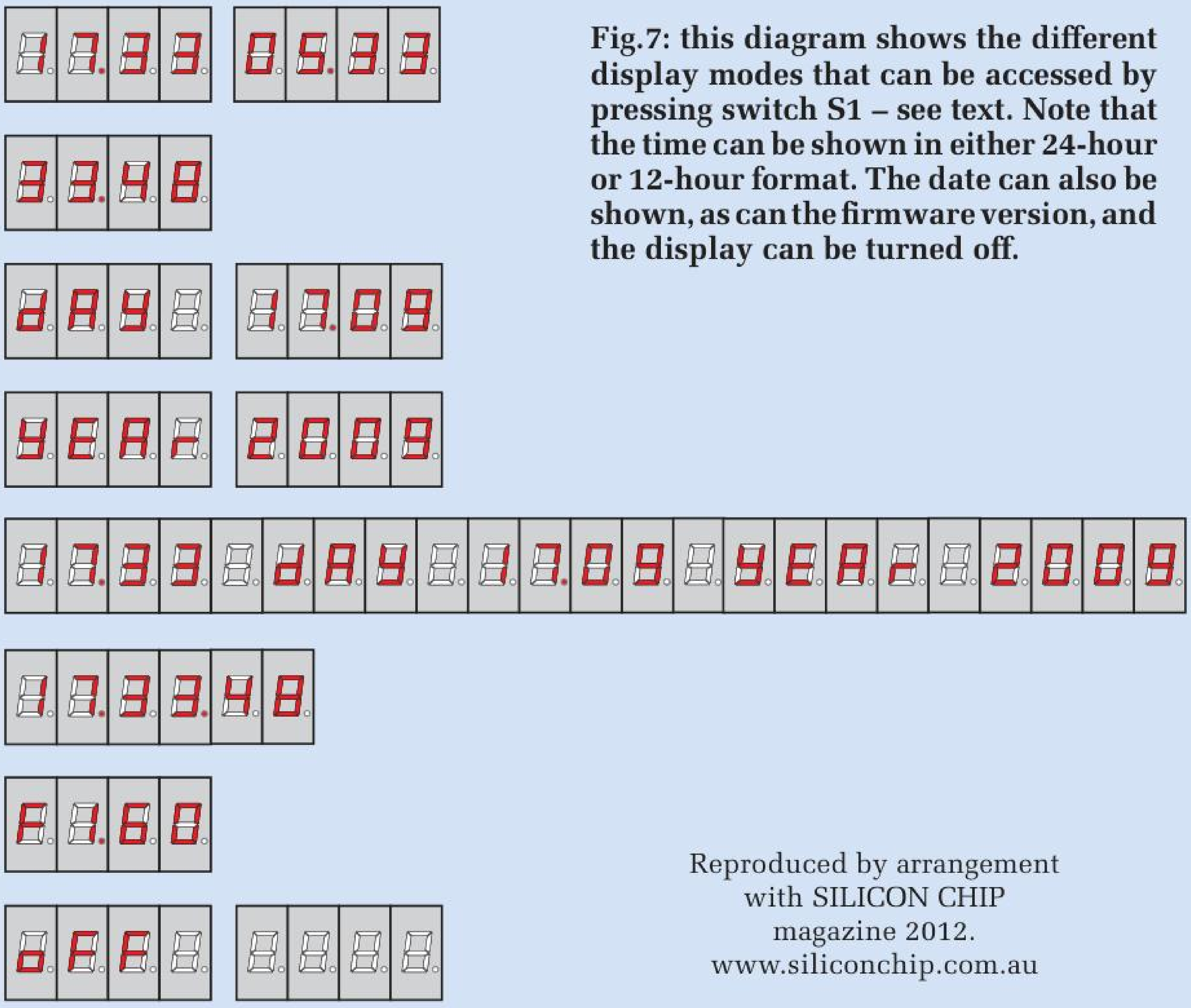


Fig.7: this diagram shows the different display modes that can be accessed by pressing switch S1 – see text. Note that the time can be shown in either 24-hour or 12-hour format. The date can also be shown, as can the firmware version, and the display can be turned off.

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Mode 3: the date in either **day.month** or **month.day** format, together with a periodically blinking display showing the word **day**.

Mode 4: the year as a 4-digit number, together with a periodically blinking display showing the word **year**.

Mode 5: the time and date shown as a continuously scrolling string.

Mode 6: the time, including the hour, minutes and seconds, shown as a continuously scrolling string.

Mode 7: the firmware version shown as an ‘F’ followed by the 3-digit version number (useful for debugging).

Mode 8: Off (the display is not driven).

Long button presses

A long button press gives a different display mode, depending on the display mode that you are already in. These are as follows:

(1) In Mode 1, it toggles the 24-hour mode on and off.

(2) In Mode 2, it takes you back to Mode 1.

(3) In Mode 3, it toggles whether the date is shown as **day.month** (eg, for UK) or **month.day** (eg, for the US).

In Modes 4 to 8, long button presses are ignored. ***EPE***

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Have you got a shed, or a boat on a mooring? Here is the ideal alarm system for it…

Solar-Powered Intruder Alarm

Solar-Powered
Alarm
Power
On
Armed
Alarm
Entry Delay
Henda
Pb

While we usually have alarms for our home and cars, a lot of valuable stuff is unprotected in garages and sheds. It also needs protecting, and now you can do it with this simple alarm based on a PIR sensor. It's solar-powered, so no mains supply is needed. And let's not forget boats on moorings – they need security too.

By JOHN CLARKE

Main features

- Three inputs
- Voltage input for PIR
- Instant or delayed option for each input
- Exit delay
- Entry delay
- Low quiescent current
- LED indicators
- Battery powered
- Solar cell battery charging

Specifications

Supply voltage	12V DC
Supply current	3mA during exit delay; 500μA with PIR connected while armed; 2.5mA plus 10mA for siren during alarm
Exit delay	22 seconds
Entry delay	approximately 5s to 30s adjustable
Alarm period	approximately 25s to 147s (2.5 minutes) adjustable
Armed flash rate	approximately once per second
Armed flash period	approximately 22ms

WHETHER YOU live in the city or country, you may have a shed with lots of valuables inside – tools, machinery, electronic equipment, sports stuff, maybe a boat – you get the picture. And we'll bet that it has no protection apart from a lock on the door. Maybe you have thought about the problem, but it was too hard and there is no mains power out there and so on.

Now you can greatly improve security for all that valuable gear with our *Solar-Powered Intruder Alarm*. As well as using a PIR sensor, it has two other inputs, so you can wire it up to suit your situation.

Now we know there are plenty of burglar alarms available, but most are too costly and complex to suit a shed – or a boat for that matter. You don't need complications like multiple sectors or back to base security – just a simple set-up with a loud siren.

Solar power

As a bonus, the simplicity of a basic alarm means a lower power requirement, so it becomes practical to power the system from a battery that is charged from solar cells.

We have specified a PIR (passive infrared) sensor intended for use with battery equipment where low current drain is a major consideration. It operates from a 5.5V to 16V DC supply, and its current drain is quoted at less than 100μA at 6V.

We measured current drain on our sample unit to be 70μA at 6V and 73μA at 12V. When movement is detected, the current rises to 1.3mA to light its indicator LED.

In its simplest form, the Solar-Powered Alarm can be used with just the PIR detector. For a shed, it is best installed inside, so that it is only triggered when somebody enters. For extra protection, reed switches can be added to monitor windows.

If you want to build this alarm for a boat, the PIR sensor is probably not practical, because sun glinting off the water could cause nuisance triggering. In this case, you would be better to rely on reed switches or a strategically placed pressure mat.

Sensor triggering

Sensor triggering can be instant or delayed. Delayed triggering allows you to enter the shed and switch off the alarm before it sounds. This would be applied to the PIR sensor if it monitors the entry point. Other sensors can be set for instant triggering.

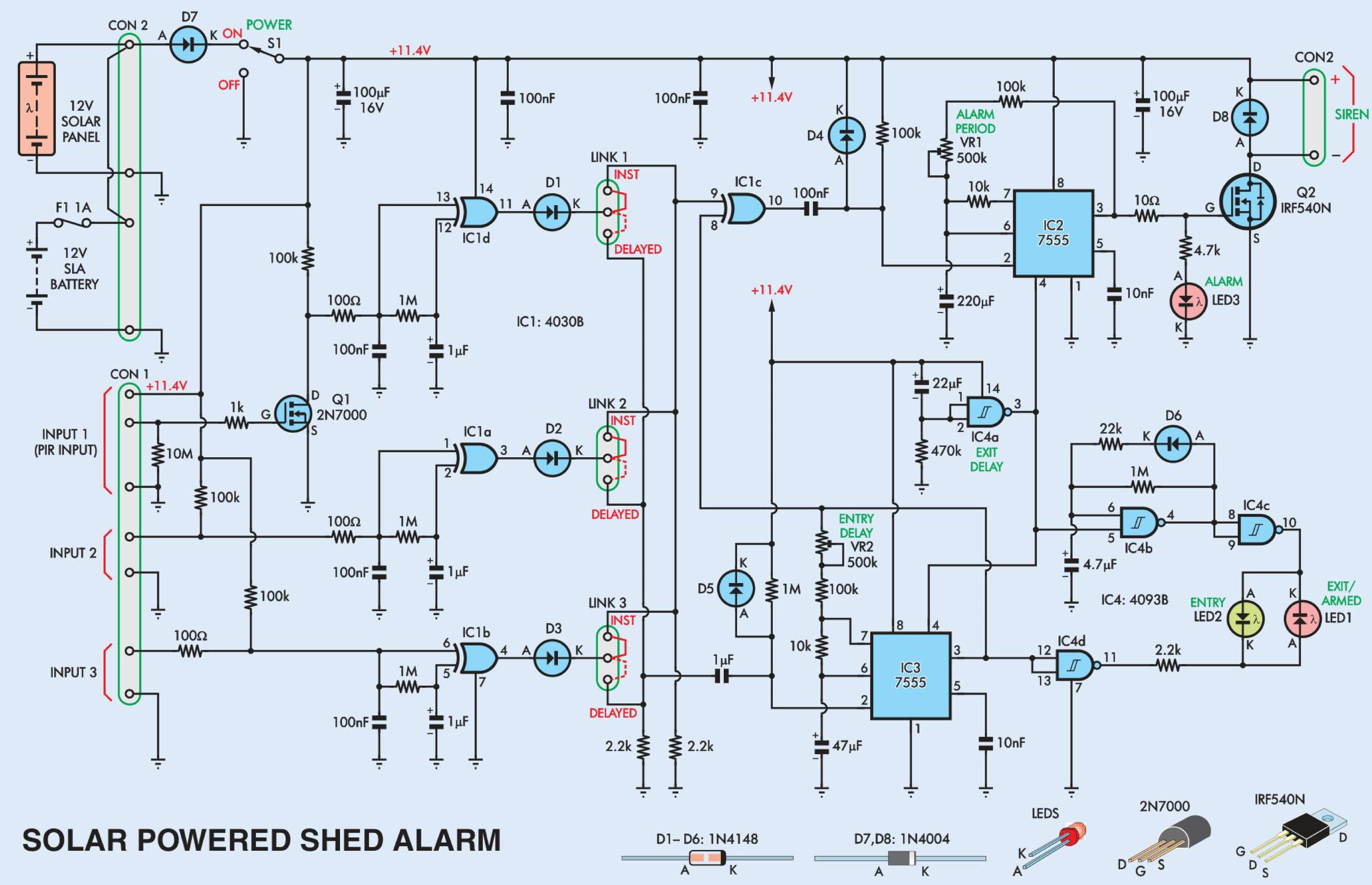
All told, there are three inputs on the alarm, each selectable for instant or delayed operation. However, that does not restrict the number of sensors to three. Most reed switch and doormat sensors can be connected in parallel, so that any sensor that closes will trigger the alarm.

Circuit details

The complete circuit of the Solar-Powered Intruder Alarm is shown in Fig.1. It looks a little complicated, but there is not a lot in it. It employs four low-cost ICs and associated components. The three inputs are labelled Input 1, Input 2 and Input 3. Input 1 is provided specifically for the PIR detector.

The output of the PIR sensor is normally 0V, but when it detects movement, it goes high to +4.5V. Its output impedance is about 700kΩ, so Input 1 employs MOSFET Q1 to provide a very high input impedance. Hence, when the PIR signal goes to +4.5V, it switches on the MOSFET and its drain (D) goes low, to 0V.

Q1 controls pins 12 and 13 of IC1d, a dual-input exclusive OR (XOR) gate.


CON 2
D7
A
K
ON
POWER
S1
OFF
+11.4V
12V SOLAR PANEL
F1 1A
12V SLA BATTERY
100µF 16V
100nF
100k
100Ω
1M
1µF
IC1d
IC1c
IC1a
IC1b
D1
D2
D3
D4
D5
D6
D8
LINK 1
LINK 2
LINK 3
INST
DELAYED
IC1: 4030B
CON 1
INPUT 1 (PIR INPUT)
INPUT 2
INPUT 3
10M
1k
Q1
2N7000
2.2k
ALARM PERIOD
VR1
500k
10k
220µF
IC2
7555
10Ω
4.7k
ALARM
LED3
10nF
Q2
IRF540N
CON2
SIREN
22µF
470k
IC4a
EXIT DELAY
22k
IC4b
IC4c
IC4d
4.7µF
IC4: 4093B
ENTRY DELAY
VR2
IC3
7555
47µF
ENTRY
LED2
EXIT/ ARMED
LED1
LEDS
D1– D6: 1N4148
D7,D8: 1N4004
G D S

SOLAR POWERED SHED ALARM

Fig.1: the circuit is based on a 4030 quad exclusive OR gate (IC1a to IC1d), two 555 timers (IC2 and IC3) and a 4093 quad 2-input NAND gate (IC4). IC2 sets the alarm period, IC3 sets the entry delay period and IC4a sets the exit delay period. IC2 also drives the siren via MOSFET Q2. Power comes from a 12V SLA battery, which is charged by a 12V solar panel.

Parts List – Solar-Powered Intruder Alarm

- 1 PC board, code 837, available from the *EPE PCB Service*, size 59mm × 123mm
- 1 UB3 plastic utility box, size 130mm × 68mm × 44mm
- 1 low-current PIR detector (IR-TEC IR-530LC) (Altronics SX-5306) – do not substitute
- 1 12V 1.3Ah or larger SLA battery (Altronics S-5075B, Jaycar SB-2480)
- 1 12V solar cell trickle charger with integral diode (Altronics N-0700, Jaycar MB-3501)
- 1 12V siren (Altronics S-6125, Jaycar LA-5258 or equivalent)
- 1 SPDT toggle switch (S1) Or
- 1 SPDT key-operated switch – see text
- 3 IP68 cable glands PG67 type
- 3 3-way PC-mount screw terminals with 5mm or 5.08mm spacings
- 2 2-way PC mount screw terminals with 5mm or 5.08mm spacings
- 1 9-way pin header broken into three 3-way headers with 2.54mm pin spacing (Link 1 to Link 3)
- 3 PC stakes
- 3 jumper plugs for above headers
- 4 4.8mm female spade connectors
- 2 4.8mm male spade connectors
- 1 60mm length of 2mm heatshrink tubing
- 1 150mm length of 0.71mm tinned copper wire or 5 × 0Ω resistors
- 1 length of 4-core alarm cable (length is installation dependent)
- 2 500kΩ horizontal-mount trimpots (VR1,VR2)
- 1 in-line 3AG fuseholder
- 1 3AG 1A fuse

Semiconductors
- 1 CD4030 quad XOR gate (IC1)
- 2 ICL7555, LMC555CN CMOS 555 timer (IC2,IC3)
- 1 CD4093 quad 2-input NAND gates (IC4)
- 1 2N7000 *N*-channel MOSFET (Q1)
- 1 IRF540 *N*-channel MOSFET (Q2)
- 6 1N4148 switching diodes (D1 to D6)
- 2 1N4004 1A diodes (D7,D8)
- 2 3mm red high-efficiency LEDs (LED1,LED3)
- 1 3mm green high-efficiency LED (LED2)

Capacitors
- 1 220μF 16V PC electrolytic
- 2 100μF 16V PC electrolytic
- 1 47μF 16V PC electrolytic
- 1 22μF 16V PC electrolytic
- 1 4.7μF 16V PC electrolytic
- 3 1μF 16V PC electrolytic
- 1 1μF monolithic ceramic
- 6 100nF MKT polyester
- 2 10nF MKT polyester

Resistors (0.25W, 1%)
- 1 10MΩ
- 5 1MΩ
- 1 470kΩ
- 6 100kΩ
- 1 22kΩ
- 2 10kΩ
- 1 4.7kΩ
- 3 2.2kΩ
- 1 1kΩ
- 3 100Ω
- 1 10Ω

Optional Additional Parts

SPDT reed switches and magnets (Altronics S-5153, Jaycar LA-5070 or equivalent)

Pressure mat (Altronics S-5184 or equivalent)

(www.altronics.com.au)

(www.jaycarelectronics.co.uk)

Both inputs are high at +11.4V when Q1 is off. When Q1 switches low, it discharges the 100nF capacitor at pin 13 via a 100Ω current-limiting resistor. With pin 13 low, the 1μF capacitor at pin 12 then discharges via the series 1MΩ resistor over a period of about one second.

IC1d's output at pin 11 is high only when the inputs differ from each other. So, when pin 13 is initially pulled low by Q1, pin 12 will remain high for a short period while the 1μF capacitor discharges. Therefore, pin 11 is high during the period that the 1μF capacitor at pin 12 is discharging.

When Q1 switches off, the 100nF capacitor at pin 13 quickly recharges via the 100kΩ resistor to the 11.4V supply. The 1μF capacitor at pin 12 is delayed from charging due to its 1MΩ charging resistor. So again, IC1d's output is set high for about a second.

As a result, IC1d's output produces a high-going pulse whenever Q1 is switched on or off by the PIR sensor.

Input 2 and Input 3 operate in a similar way to Input 1, except that no MOSFET is used and the 100nF capacitor is discharged via the normally open (NO) sensor contacts between input and ground (0V). The 100Ω series resistor reduces peak current through the contacts to less than 120mA.

We recommend using NO sensor switches because if normally closed (NC) switches are used, the 100kΩ resistor connecting to the 11.4V supply would add an additional 114μA to the overall current drain of the circuit.

Triggering

The three XOR gate outputs (ie, IC1a, IC1b and IC1d) are coupled via diodes to links that give the option of 'instant' and 'delayed' triggering.

The instant option connects to pin 9 of IC1c, which is normally held low by a 2.2kΩ resistor. A high signal from the output of IC1a, IC1b or IC1d will pull pin 9 high, and output pin 10 of IC1c will go high whenever the pin 8 input is low (which is most of the time).

Hence, each time one of the XOR gate outputs goes high, pin 10 will produce a brief positive pulse of the same duration. This pulse is coupled via a 100nF capacitor to the trigger input (pin 2) of IC2, a CMOS 7555 wired as a monostable. This is the Alarm Period timer. It determines how long the siren sounds after the alarm has been triggered.

Normally, pin 2 of IC2 is pulled high via the associated 100kΩ resistor, and since IC1c's output is normally low, the 100nF capacitor will be fully charged. Then, when pin 10 of IC1c goes high momentarily, it attempts to force pin 2 of IC2 above the positive supply, because of the positive charge on the 100nF capacitor. However, diode D4 prevents this from happening, and any excess voltage from the capacitor is safely limited.

After the short positive pulse from IC1c, pin 2 of IC2 will then be briefly pulled low via the 100nF capacitor, and this sets monostable IC2 running for its predetermined alarm period. Output pin 3 will go high and this will turn on MOSFET Q2, which then drives the external siren connected to CON2. LED3 is also lit, indicating an alarm condition.

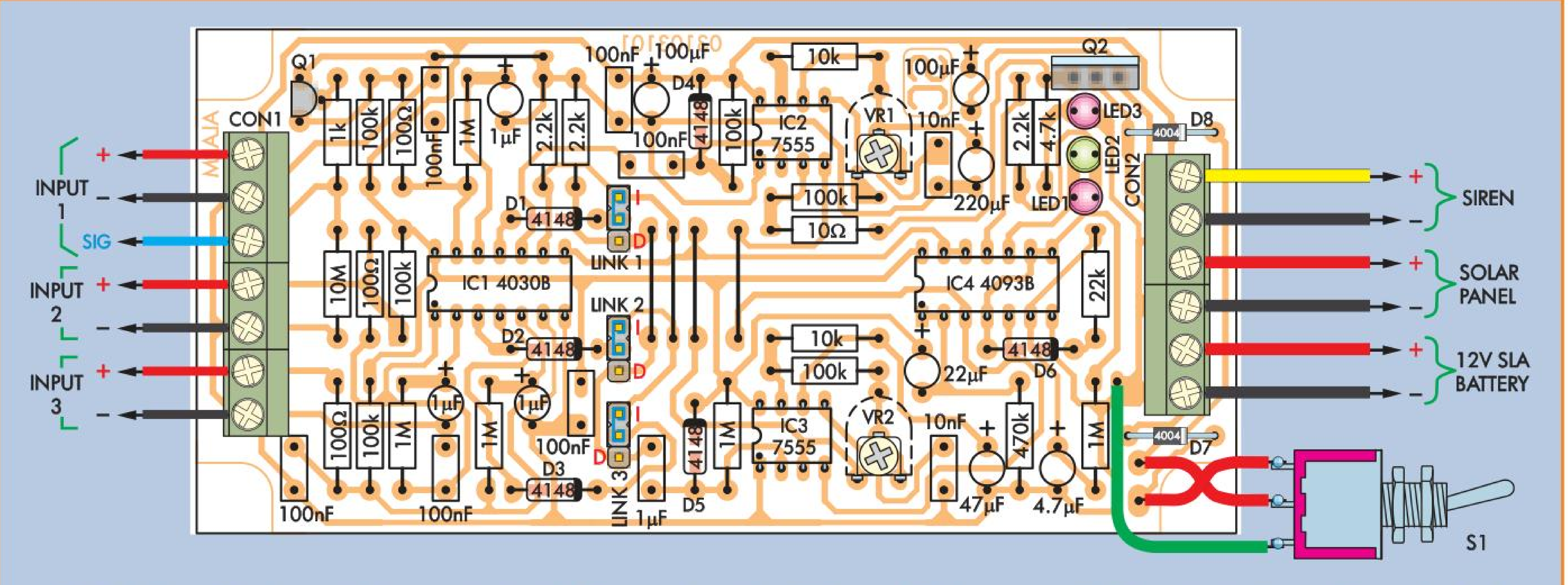


Fig.2: follow this layout diagram to install the parts on the PC board. Take care with the orientation of the polarised components and position Link 1 to Link 3 to select either instant or delayed triggering for each input.

At the same time, the 220µF capacitor at pin 6 begins to charge via the 100kΩ resistor and 500kΩ trimpot VR1. When it reaches $^2/_3$ of the supply voltage, the timer is switched off, with pin 3 going low. At the same time, pin 7 discharges the 220µF capacitor via the 10kΩ resistor.

Note that the resistors from pin 7 are connected to the pin 3 output of IC2, rather than the 11.4V supply. This arrangement is used to minimise current drain.

Exit and entry delay

An exit delay is needed, so that when you power up the alarm, you have time to get out of your shed (or boat) without triggering the siren. Switch S1 powers up the alarm circuit. When power is applied, the 22µF capacitor at pin 1 and pin 2 of IC4a is initially discharged and this sets the output of this Schmitt NAND gate low, to hold the reset for both the IC2 and IC3 timers low. This prevents IC2 and IC3 from being triggered.

The 22µF capacitor then charges via the 470kΩ resistor and after about 45 seconds or so, the voltage reaches the lower threshold for IC4a's input and its pin 3 output goes high. Thus, pin 4 on both IC2 and IC3 goes high, and both of these timers can now be triggered, ie, the alarm circuit is fully operational.

IC3 is another 7555 wired as a monostable timer; it is used for the entry delay. It is triggered if one of the links (Link1 to Link3) is set for delayed triggering. The trigger pulse for pin 2 of IC3 is coupled via a 1µF capacitor. One side of the 1µF capacitor is normally held low via a 2.2kΩ resistor to ground, while the pin 2 side is held high via a 1MΩ resistor.

Again, the triggering process is similar to that for IC2. When a high signal is applied from one of the diodes, D1, D2 or D3, the 1µF capacitor discharges via the now forward-biased diode D5. When the delayed signal side of the capacitor goes low, the pin 2 input to IC2 is pulled low to trigger the timer.

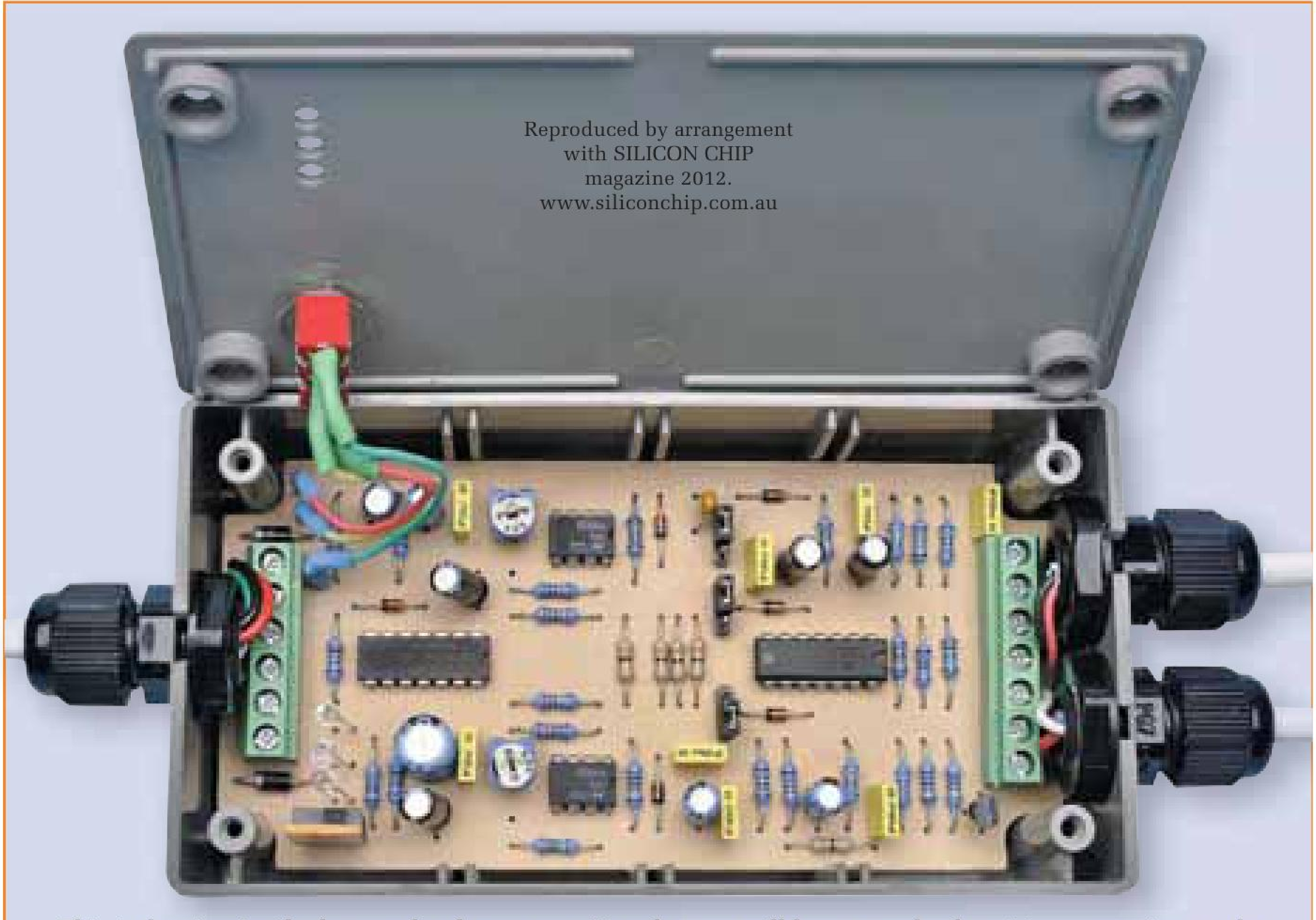
The pin 3 output of IC3 will then go high for the entry delay period, which is set by trimpot VR2. This holds the pin 8 input of IC1c high, which prevents IC2 from being triggered.

The entry delay can be set anywhere between five seconds and 30 seconds.

Let's clarify a point here. When we talk about 'entry delay', we are referring to the delay which is available when any of the three input sensors closes, provided that 'Delayed Triggering' has been selected by the link options provided by Link 1, 2 or 3 (or any combination of the three).

Table 1: Resistor Colour Codes

☐	No.	Value	4-Band Code (1%)	5-Band Code (1%)
☐	1	10MΩ	brown black blue brown	brown black black green brown
☐	5	1MΩ	brown black green brown	brown black black yellow brown
☐	1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
☐	6	100kΩ	brown black yellow brown	brown black black orange brown
☐	1	22kΩ	red red orange brown	red red black red brown
☐	2	10kΩ	brown black orange brown	brown black black red brown
☐	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
☐	3	2.2kΩ	red red red brown	red red black brown brown
☐	1	1kΩ	brown black red brown	brown black black brown brown
☐	3	100Ω	brown black brown brown	brown black black black brown
☐	1	10Ω	brown black black brown	brown black black gold brown



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This is the view inside the completed prototype. Note that you will have to make the wiring connections to the screw terminal blocks before sliding the PC board into the case and installing the cable clamps.

LED indicators

During the exit delay period, pin 5 of Schmitt NAND gate IC4b is held low and its pin 4 output remains high. IC4c inverts this high, and so its output at pin 10 is low. Pin 3 of IC3 is low (since IC3 is currently disabled) and so pin 11 of inverter IC4d is high. The combination of pin 11 being high and pin 10 being low means that LED1 is lit continuously for a period of 45 seconds, which is the Exit Delay.

After the Exit Delay period, the pin 3 output of IC4a allows normal operation for timers IC2 and IC3. It also allows the oscillator based on IC4b to operate by pulling pin 5 high. This now flashes LED1 at about once every two seconds.

The duty cycle of the oscillator is only about 2%, so while the flashing of LED1 is highly visible, the overall LED current drain is very low.

During the entry delay period, IC4d's output at pin 11 is low, so LED1 is off and green LED2 is on, but not continuously. This is because the oscillator based on IC4b is still running and LED2 turns off very briefly every two seconds.

At the end of the Entry Delay period, IC3's output (pin 3) goes low again and pin 11 of IC4d goes high. This causes LED1 to flash again and the alarm will sound, since IC2 has been enabled. This lights LED3 and sounds the siren connected to MOSFET Q2.

Of course, if the Entry Delay was triggered by you, entering in a legitimate way, you will have had time to turn off the alarm and the neighbourhood will not be disturbed.

Construction

The Solar-Powered Intruder Alarm is constructed on a PC board, coded 837, measuring 59mm × 123mm. This board is available from the *EPE PCB Service*. The PC board is designed to clip into the integral mounting clips inside a UB3-size plastic case.

Fig.2 shows the assembly details. Begin construction by checking the PC board for breaks in the tracks or shorts between tracks and pads. Repair these if necessary.

Check that the hole sizes are correct for each component. The screw terminal holes are 1.25mm in diameter, compared to the 0.9mm holes for the ICs, resistors and diodes.

Assembly can begin by inserting the links, diodes and resistors. We used 0Ω resistors in place of wire links, although tinned copper wire links could be used instead. When inserting the resistors, use the resistor colour code table to help in reading the resistor values. If available, a digital multimeter should be used to check each value.

The diodes can be installed next, and these must be mounted with the orientation shown. The four ICs can then be mounted directly on the PC board or using sockets. DIP14 IC

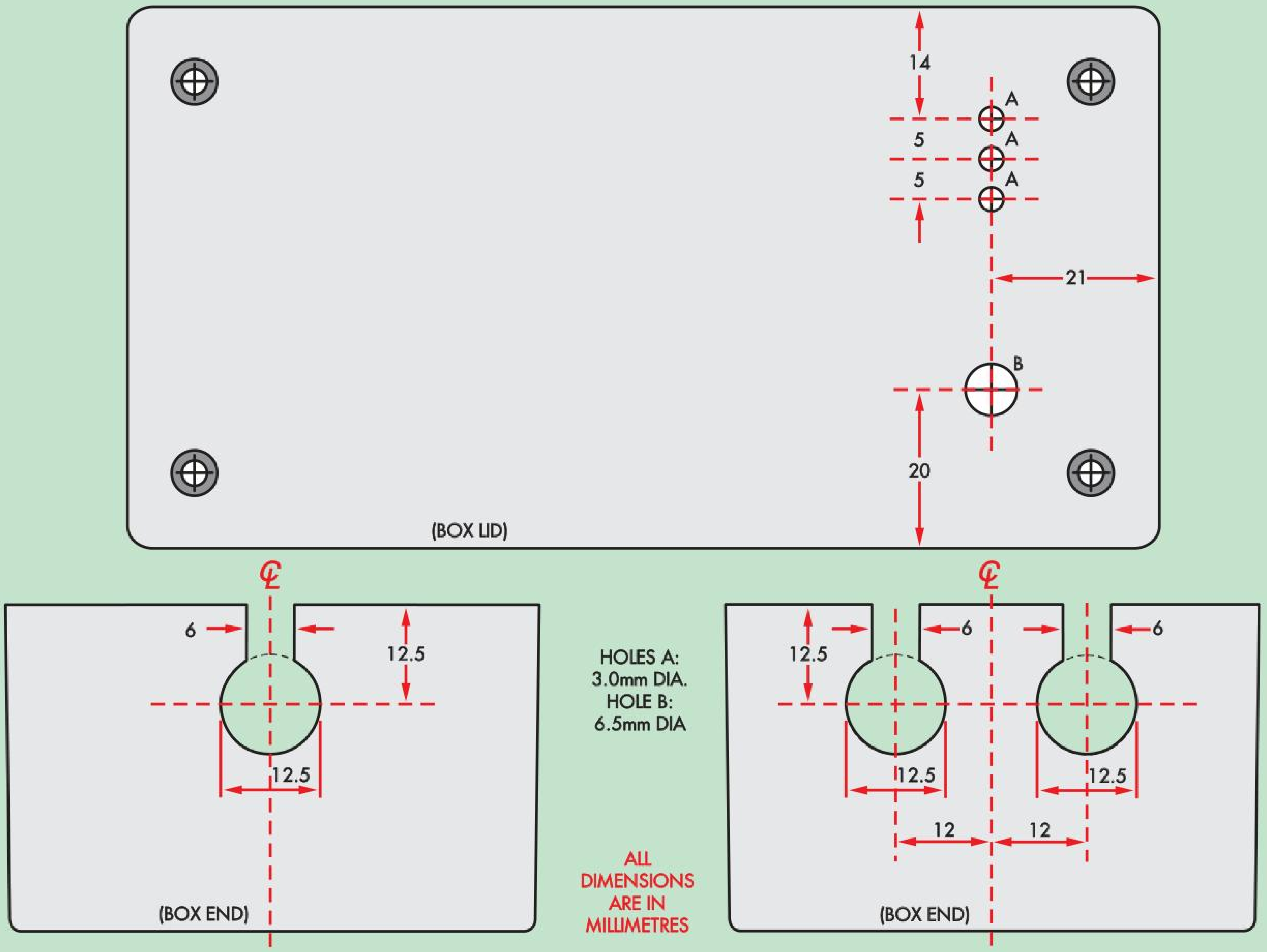


Fig.3: this diagram shows the drilling details for the lid and the two ends of the case. The larger holes (ie, >3mm) are best made by first using a small pilot drill and then carefully enlarging them to the correct size using a tapered reamer.

sockets are required for both IC1 and IC4 and DIP8 sockets for IC2 and IC3.

Ensure that each IC is placed in its correct position and is oriented correctly, with its notch or pin 1 indicating dot oriented as shown. The two trimpots can now be mounted, followed by MOSFETs Q1 and Q2, taking care with their orientation. The multi-way screw terminals can then go in, noting that the 7-way terminals are made using one 3-way and two 2-way sections. The 6-way terminals are made using two 3-way sections.

The three LEDs are mounted with the top of each LED 28mm above the PC board. Take care with orientation. The anode has the longer lead.

Follow with the capacitors, ensuring that the electrolytic types are oriented correctly. Finally, insert and mount the three 3-way pin headers and the three PC stakes.

As mentioned, the PC board is designed to snap into the integral side clips within the box. The box requires holes to be drilled in each end for the cable glands. Note that there are also 6mm slots cut from the top edge of the box to the cable gland holes – see Fig.3. These are there to make assembly possible, but more on this later. Holes are also required in the lid for the LEDs and power switch. Fig.3 shows the dimensions for these.

Wiring

The wiring for the switch and siren is shown in Fig.2. The switch wiring is soldered to PC stakes on the board and the connections covered with a 10mm length of heatshrink tubing to prevent them from breaking. The external siren is connected to the screw terminals.

Testing

To test the unit, connect a 12V supply to the '+' and '–' terminals on the PC board, apply power and check that LED1 lights. If LED2 lights instead of LED1, then the orientation of LED2 is reversed. If neither LED lights, check LED1's orientation.

The length of time LED1 stays fully lit is the Exit Delay period. This delay is not critical, but it does need to be sufficient to allow an easy exit from the shed after switching on the alarm without setting it off. You can change the exit period by changing the capacitor value at pins 1 and 2 of IC4a.

A smaller value will reduce the period, while a larger value will give a longer period.

Select each input for either instant or delayed triggering using the jumper pin option for each input. Note that an input will be disabled if there is no jumper connection.

When red LED1 begins to flash, the alarm is ready to be triggered. Connect a wire between the two contacts for input 2. For an instant alarm selection, red LED3 should immediately light. For a delayed selection, green

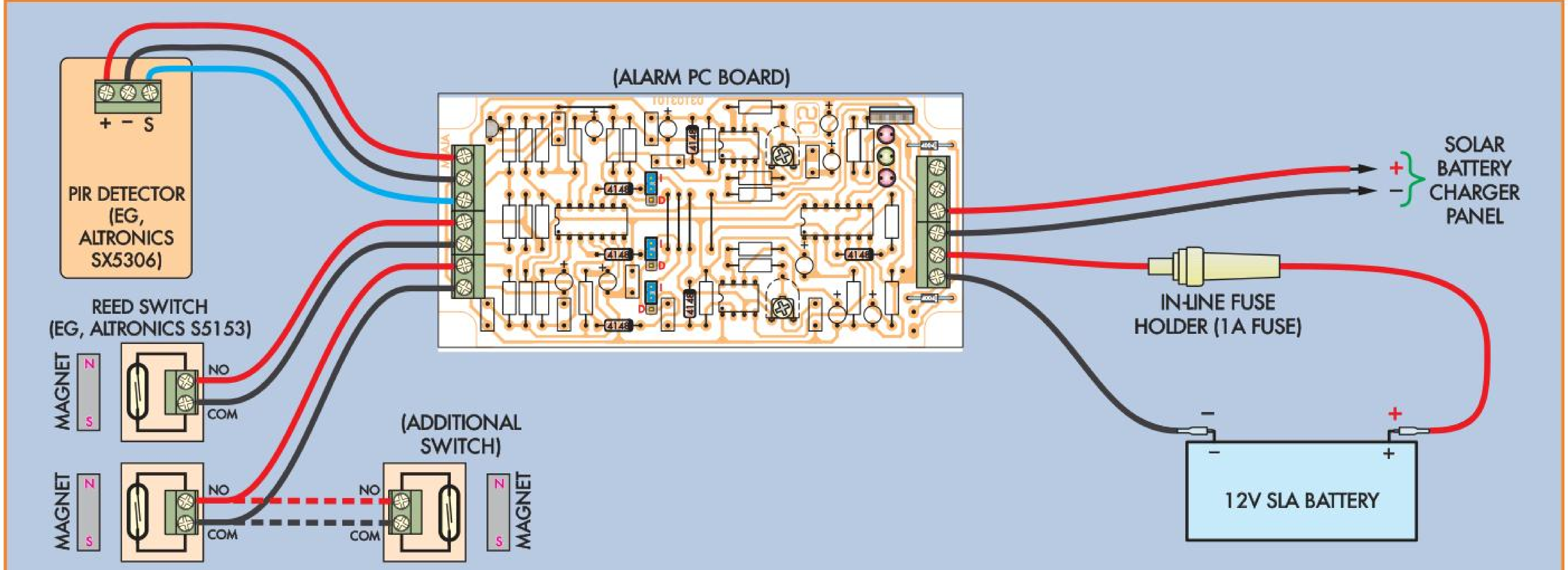
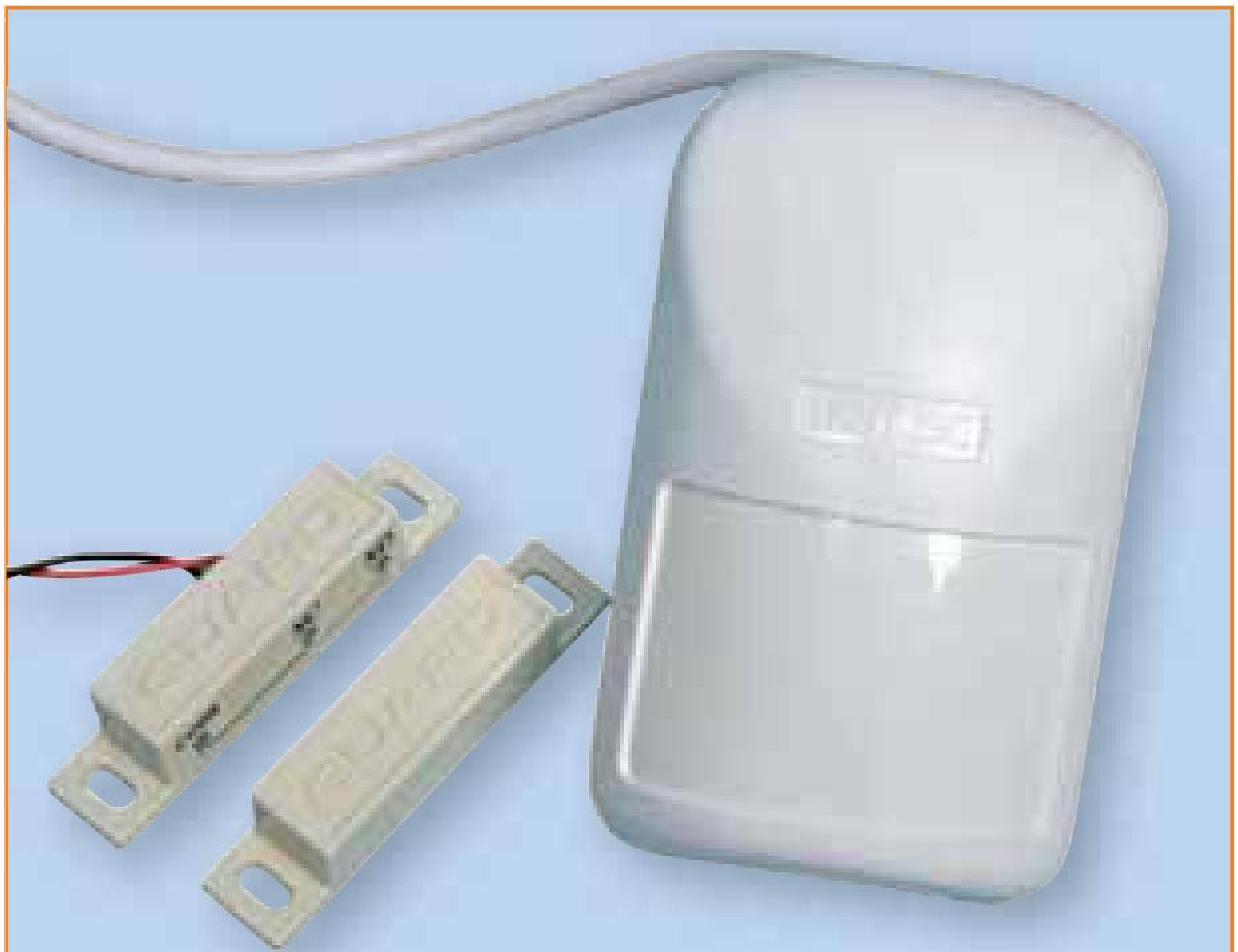

(ALARM PC BOARD)
+ − S
PIR DETECTOR (EG, ALTRONICS SX5306)
REED SWITCH (EG, ALTRONICS S5153)
MAGNET
N
S
NO
COM
(ADDITIONAL SWITCH)
SOLAR BATTERY CHARGER PANEL
+
−
IN-LINE FUSE HOLDER (1A FUSE)
12V SLA BATTERY

Fig.4: the PIR detector and reed switch sensors are connected to the PC board as shown here. Not shown are the connections to the siren and the on/off switch. Be sure to use a 1A fuse in series with the battery supply.



A PIR detector and some SPDT reed switches make ideal sensors for the Solar-Powered Alarm. Fig.4 shows how they are connected.

LED2 should light. When LED2 extinguishes, LED3 should light.

If the siren is connected, it will also sound, but due to its loudness, you may wish to disconnect this during testing. Alternatively, you could connect a piezo sounder instead.

The Alarm Period can be set with trimpot VR1. Clockwise rotation increases the period, while anticlockwise rotation reduces the period. The Alarm Period only needs to be long enough to attract your attention to the fact that there may be an intruder. An extra long alarm period is not necessary.

The Entry Delay period is set using trimpot VR2. This period should be as short as possible, but still provide sufficient time for you to gain entry to the shed to switch off the alarm. Final adjustment will be best done after the alarm system is installed in the shed (or boat).

Installation

Wiring for the Solar-Powered Alarm is influenced by the installation. It depends on the number of sensors used and the distance between the sensors. Wire lengths are also dependent on the location of the battery and the solar cell in relation to the alarm unit.

The solar panel should be mounted on the roof of the shed, and in the UK should be set facing south. (Southern hemisphere installations will have the solar cell unit facing north). UK inclination should be roughly 30° up from horizontal. Precise inclination is not critical. Provided it's in the ballpark, the solar cell output will be more than adequate to keep the SLA battery charged, unless the alarm is repetitively activated each day.

Decide on the type of sensor you will use with the alarm. Typically, a reed switch and magnet are used to monitor a door or window. The magnet is installed on the moving part and the reed switch mounted on the fixed part.

The normally open (NO) contacts of SPDT reed switches should be used, to provide a lower current drain from the battery. These contacts are open when the magnet is close to the reed switch, but close as the magnet moves away from the reed switch.

The NO contacts can be connected in parallel so that more than one window or door can be monitored on one input. However, the door entry reed switch should be connected to a different input than the window sensors, so that the window inputs can be set

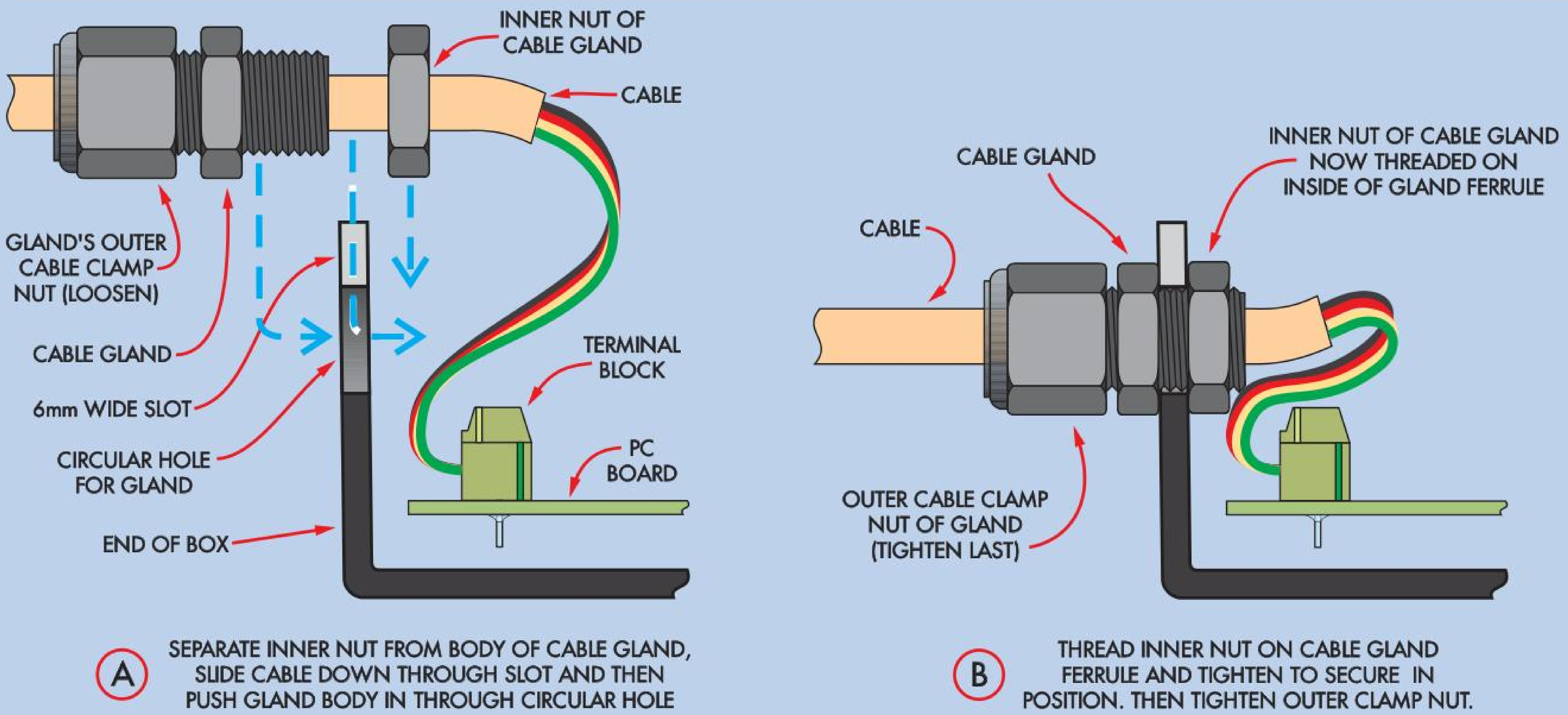
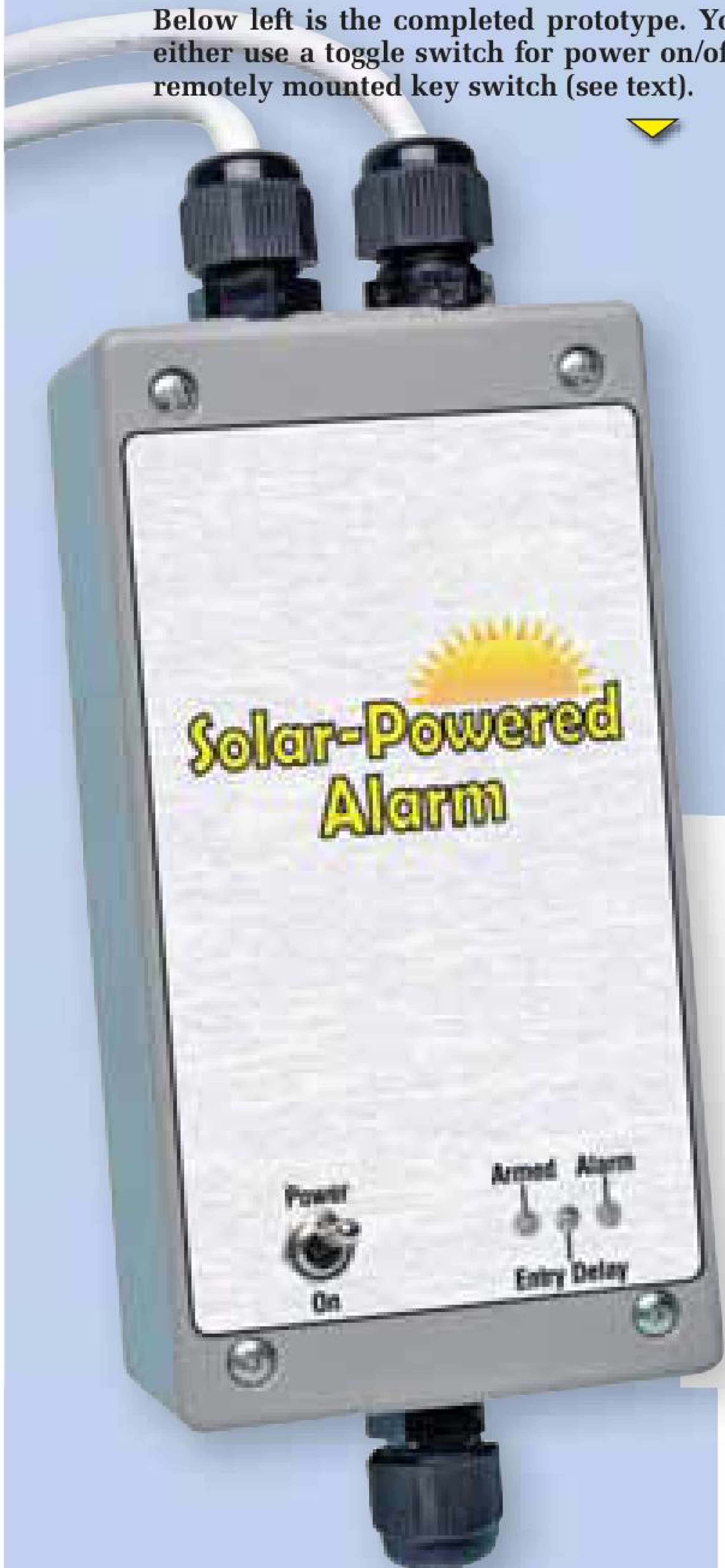

INNER NUT OF CABLE GLAND
CABLE
GLAND'S OUTER CABLE CLAMP NUT (LOOSEN)
CABLE GLAND
6mm WIDE SLOT
CIRCULAR HOLE FOR GLAND
END OF BOX
TERMINAL BLOCK
PC BOARD
A
SEPARATE INNER NUT FROM BODY OF CABLE GLAND, SLIDE CABLE DOWN THROUGH SLOT AND THEN PUSH GLAND BODY IN THROUGH CIRCULAR HOLE
CABLE GLAND
INNER NUT OF CABLE GLAND NOW THREADED ON INSIDE OF GLAND FERRULE
CABLE
OUTER CABLE CLAMP NUT OF GLAND (TIGHTEN LAST)
B
THREAD INNER NUT ON CABLE GLAND FERRULE AND TIGHTEN TO SECURE IN POSITION. THEN TIGHTEN OUTER CLAMP NUT.

Fig.5: the cable glands are slid into the case slots and secured after the leads have been secured to the screw-terminal blocks, as shown here. Note that the outer cable clamp nut is tightened last.

Below left is the completed prototype. You can either use a toggle switch for power on/off, or a remotely mounted key switch (see text).

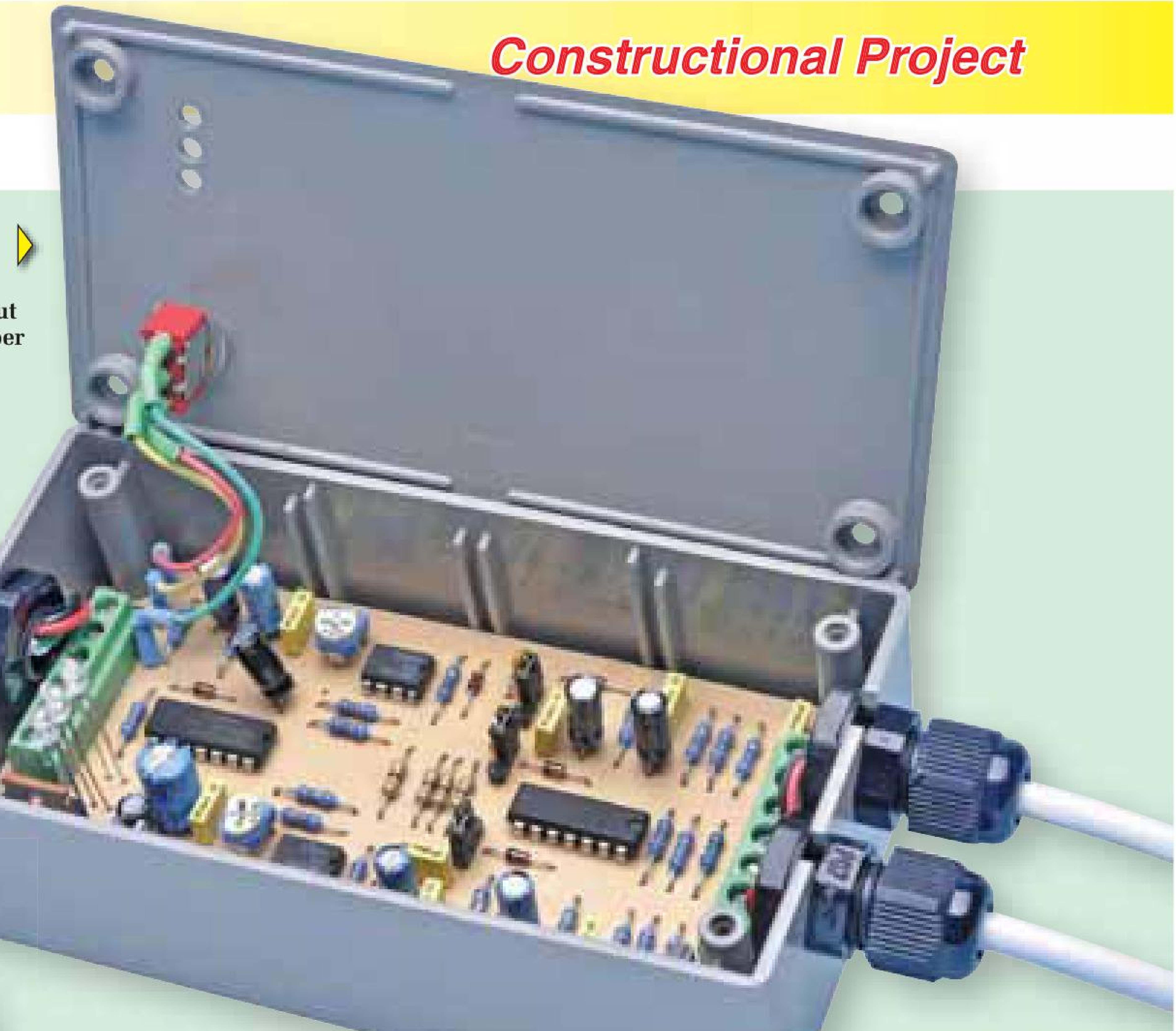

Solar-Powered Alarm
Power
On
Armed
Alarm
Entry Delay

to an instant alarm. The door entry is normally set for a delayed alarm to allow entry into the shed to switch the unit off.

The PIR sensor should be mounted so that it covers as much of the shed as possible. You can test coverage by connecting a 12V supply to the PIR detector, temporarily mounting it in position and watching the detector LED light as you move around the shed.

Note that while we used a toggle switch on the Solar-Powered Alarm to switch it on and off, an SPDT keyswitch could be used instead. This keyswitch could then be mounted outside near the door of the shed, so that the alarm can be switched on and off from outside the shed.

Using a keyswitch allows the entry delay to be set to a very short period or set to instant. Note, however, that the Exit Delay needs to be at least a second to ensure that the Solar-Powered Alarm is reset properly at power up. The Exit Delay capacitor should therefore be at least 2.2μF.



At right is another view inside the completed prototype. We used 0Ω resistors for the links, but you can use tinned copper wire instead.

The Altronics N-0700 12V solar cell trickle charger includes an integral diode and is used to keep the 12V SLA battery topped up. At right is the full-size front-panel artwork

The external siren should be mounted high in an inaccessible position, and the wiring to it hidden so that is cannot be cut.

External wiring

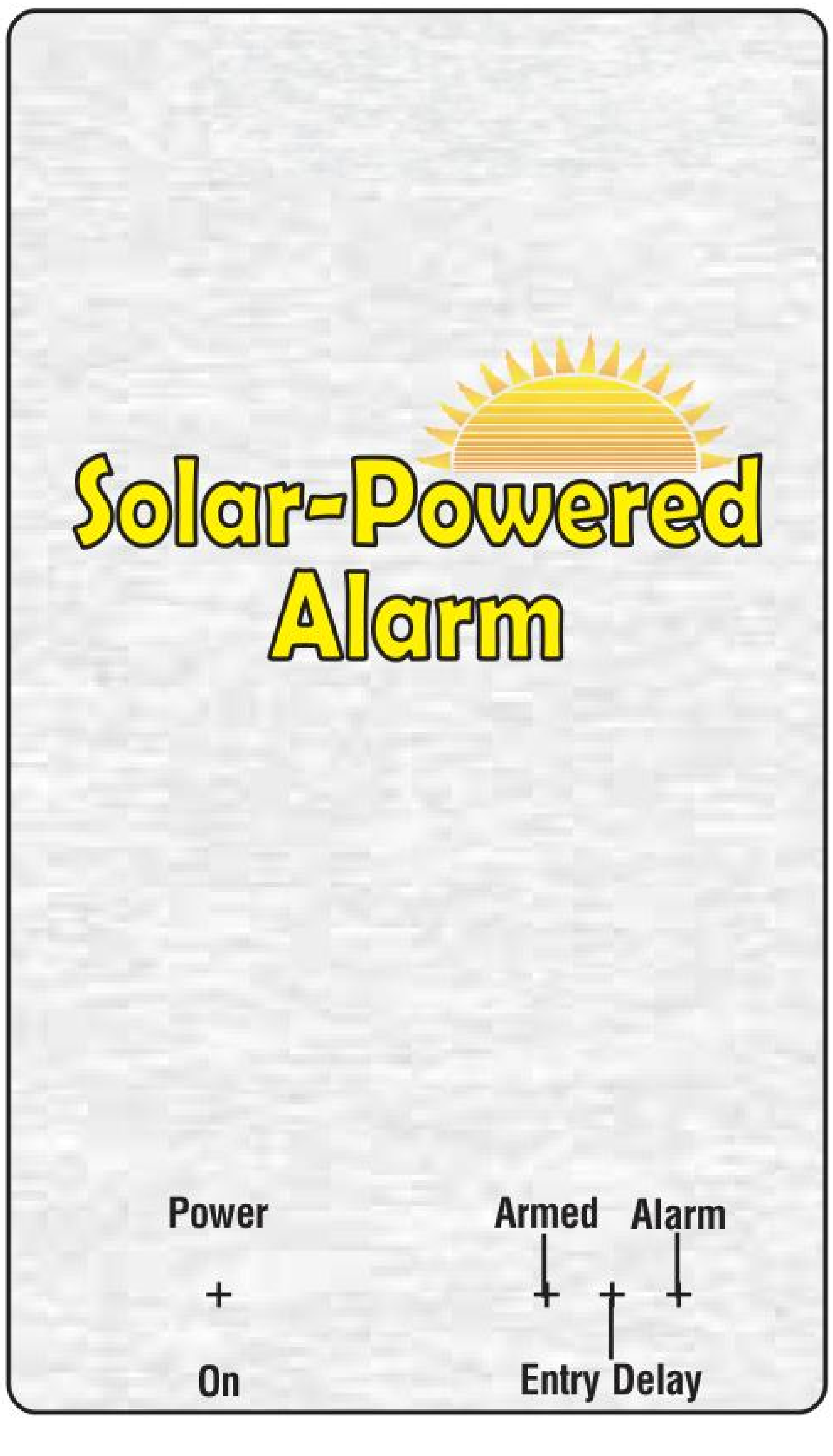
The wiring for the battery, solar cell and trigger inputs is shown in Fig.4. This wiring can be done with the PC board out of its box and with just the wiring passing through the cable glands. The glands are not secured into the box until later.

Wiring for the PIR uses 4-core cable, which is passed through its own cable gland. One of the wires is not used and is cut short. Another cable gland is for the Input 2 and Input 3 cabling, and this also uses 4-core cable.

Four-core cable is also used for the battery and solar cell. **Use an in-line fuse holder for the positive battery connection.** The battery wires are secured to 4.8mm female spade connectors using a crimp tool. These connectors plug into the spade battery terminals.

The solar-cell charger is supplied with a lighter plug on the end of its lead. This can be cut off and 4.8mm female spade connectors attached instead. These can then go to male spade connectors that are attached to the solar cell leads from the alarm unit.

When assembling the Solar-Powered Intruder Alarm into its box, first clip the PC board into the box and place each cable gland securing nut inside the box and the gland on the outside of the box. Pass the cable wires through the slots, as shown in Fig.5. Tighten the gland to the box against its nut and then clamp the cable in place with the cable clamp. ***EPE***



Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

ON THE face of it, dealing with components that have only two leads is very straightforward, it is just a matter of fitting components of the right values in the right places on the circuit board. With many twin lead components it is indeed as simple as that, and there should be no problems when dealing with resistors, inductors and most capacitors. However, there is a slight complication with some twin lead components in that they are polarised and *must* be fitted to the circuit board the right way round.

In most instances, where a polarised component is fitted the wrong way round there will not be any dire consequences, but it is unlikely that the project will actually work until the error is corrected. Unfortunately, in a few cases it is likely that getting the polarity of one or more components wrong will have serious consequences. An error of this type can result in burned-out semiconductors and exploding electrolytic capacitors!

The 'suck it and see' approach is not usually acceptable when dealing with polarised components. It could result in a lot of ruined components and could even be dangerous. Consequently, due care *must* be exercised when fitting any polarised component.

One way system

Most semiconductors have three or more leads or pins, but there are a few types that have just two. By far the most common of these are the various kinds of diode and rectifier.

These two types of component provide exactly the same function, which is to act like an electronic valve. In other words, an electric current can flow through the component in one direction, but any significant current flow is blocked in the opposite direction. Diodes are used in low-power applications, whereas rectifiers are designed to handle high currents.

Connecting a diode with the wrong polarity allows a current flow in the wrong direction, while blocking any flow of current in the right direction. Due to the low-powers involved, this will not normally cause any damage, but in a few applications it could result in instant destruction of the diode.

The situation is very different with rectifiers, where the high currents involved more or less guarantee that a polarity error will result in damage to some of the components. Clearly it is necessary to take extra care when dealing with rectifiers.

As one would probably expect, diodes are physically quite small, but rectifiers are generally much larger, although the lower power types are not actually that much larger than a typical diode. Rectifiers have been produced in a wide range of shapes and sizes, but most of the more elaborate case styles are now obsolete.

In fact, the majority of rectifiers now look like outsize diodes, which is what they actually are. In most cases, there is no difficulty in getting diodes and rectifiers fitted with the correct polarity, but a few types are, to say the least, a bit confusing.

Symbolism

Most diodes are quite easy to deal with, and they are normally in the form of small components that look a bit like resistors. They mostly have plastic or glass encapsulations with a band of contrasting colour marked around one end of the case. The two terminals of a diode are called the 'anode' and 'cathode', and these have the abbreviated forms of 'a' and 'k' respectively.

The circuit diagrams in *Everyday Practical Electronics* include the 'a' and 'k' markings, but they will not necessarily be included in circuit diagrams found elsewhere. A '+' sign is often used in place of the cathode marking, possibly accompanied by a '–' sign instead of the anode marking.

None of these markings are actually required though, since the polarity is indicated by the basic diode symbol itself. However, they could be useful to those having limited experience with circuit diagrams.

In terms of conventional current flow, the arrowhead part of the diode symbol indicates the direction in which a current is allowed to flow. The bar across the end of the arrowhead is at the cathode (k) end of the symbol, and this corresponds with the coloured band around the body of a diode, which is also at the cathode end of the component.

A single band marked around the body of a diode is by far the most common method of polarity indication, but there are two other types that you may well encounter. Fig.1 shows the circuit symbol for a diode, together with physical representations for the common types of rectifier and diode. In general, the bodies of diodes are rounded at the ends, whereas those of rectifiers are flat, and in the case of high current rectifiers they are also physically much larger.

Colour coding

One method of marking is potentially a little confusing, as it uses additional bands around the body of the component. There are three or four bands with this system, and they indicate the type number

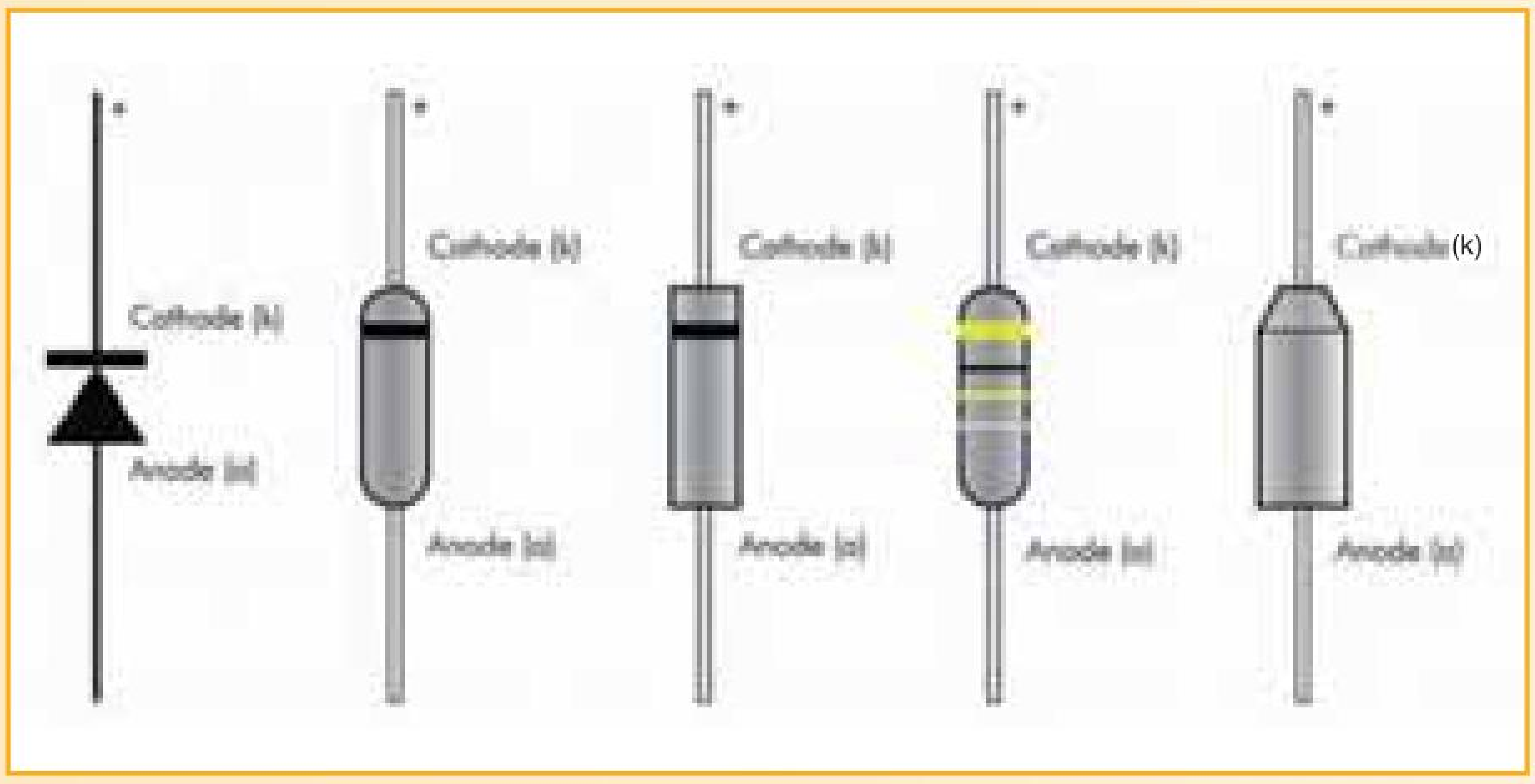


Fig.1. The diode circuit symbol (left) together with various methods of identifying the anode and cathode leads of real-world rectifiers and diodes. All these methods are loosely based on the circuit symbol

of the component using a system of colour coding that is based on the one used for resistors.

As far as I am aware, this system is only used for diodes that have American type numbers with a '1N' prefix. No multipliers are used with this system, which works on the straightforward basis of one band per digit of the serial number.

There is an obvious flaw with this method, in that it no longer has a single band to indicate the cathode end of the component. The way around this is to have the band that indicates the cathode end of the component substantially wider than the other two or three bands – see Fig.1.

Also, this band is usually very close to its end of the component and the cathode lead. Unfortunately, these pointers are often quite difficult to spot and it is often necessary to carefully study one of these components in order to determine its polarity.

Some rectifiers use a totally different method of polarity indication, and this is to have the body of the component much narrower next to the cathode lead. This corresponds to the thinning of the diode circuit symbol towards the cathode end (see Fig.1). It is possible that this method is also used for diodes, but I have only encountered it with rectifiers. Many rectifiers, and particularly the smaller types, use the single coloured band method of polarity indication.

Seeing the light

I can state, with a fair amount of confidence, that it is the light emitting diode (LED) that causes the most problems when it comes to getting the polarity of diodes correct. It is important to realise that a light emitting diode is a true diode, and unlike a filament bulb, it will not light up unless it is fed with a voltage of the correct polarity.

The early light emitting diodes mostly had the polarity indicated using two methods, one of which was to have the cathode (k) lead shorter than the anode one. The second method was to have the round casing/body flattened slightly near the cathode lead.

Many modern light emitting diodes use one or both of these methods, but some seem to lack any obvious method of polarity indication. Matters are confused by the fact that modern light emitting diodes come in a huge range of shapes and sizes. In some cases, the old methods of polarity indication are simply inappropriate. In other cases, there is no obvious reason for one of the traditional methods of polarity marking not being included.

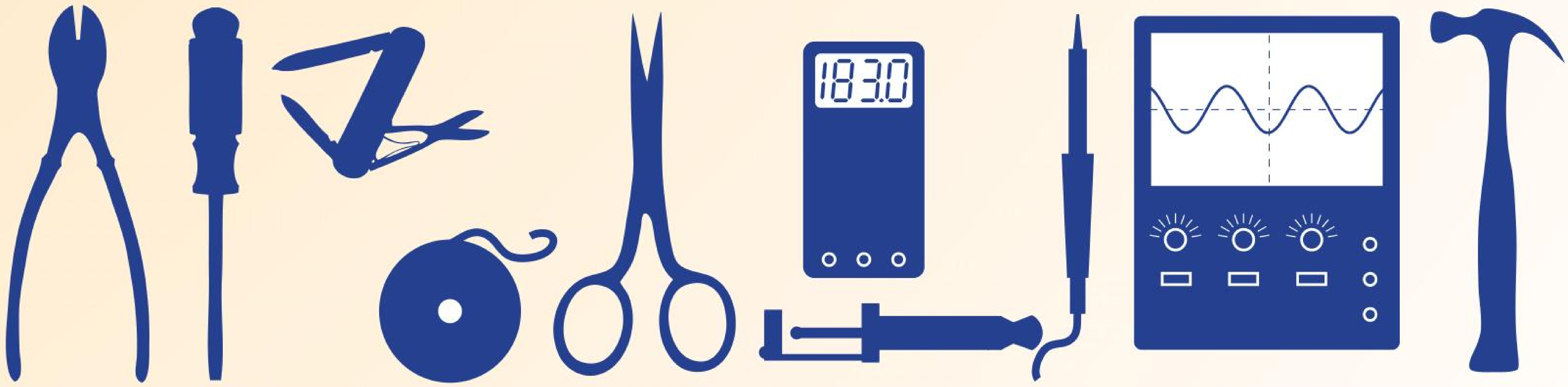
Ideally, there would be a 'sure-fire' method of determining the polarity of a light emitting diodes without resorting to some form of electronic testing. Various ways have been suggested over the years, but there always seems to be some light emitting diodes that 'buck the trend', or where the unusual physical construction of some components render these methods unusable.

With more exotic LEDs it might be necessary to consult the supplier's catalogue or the manufacturer's data sheet, but careful scrutiny of the construction diagrams for the project should really tell you all you need to know. Looking on the bright side, it is very unlikely that one of these components will be damaged if you should happen to get it connected the wrong way around. If you do make a mistake, everything should be fine once the error has been corrected.

Of course, in some cases it could be difficult to correct things if you do not get it right first time. You certainly need to know the correct method of connection before dealing with banks of LEDs or multi-pin components that contain several LEDs.

Due to the inconsistent nature of these components, it is advisable to check the polarity of LEDs before connecting them into circuit. Any multi-range test meter should have a facility for checking the polarity of diodes. However, LEDs have relatively high forward threshold voltages, and this prevents them from being checked using some meters.

It makes sense to use a test meter to check LEDs if you have a suitable instrument available. If not, a simple test circuit can be improvised, and the arrangement of Fig.2 will suffice. The circuit is so simple that it can easily be constructed on a breadboard, or it can even be wired together using crocodile clip leads.



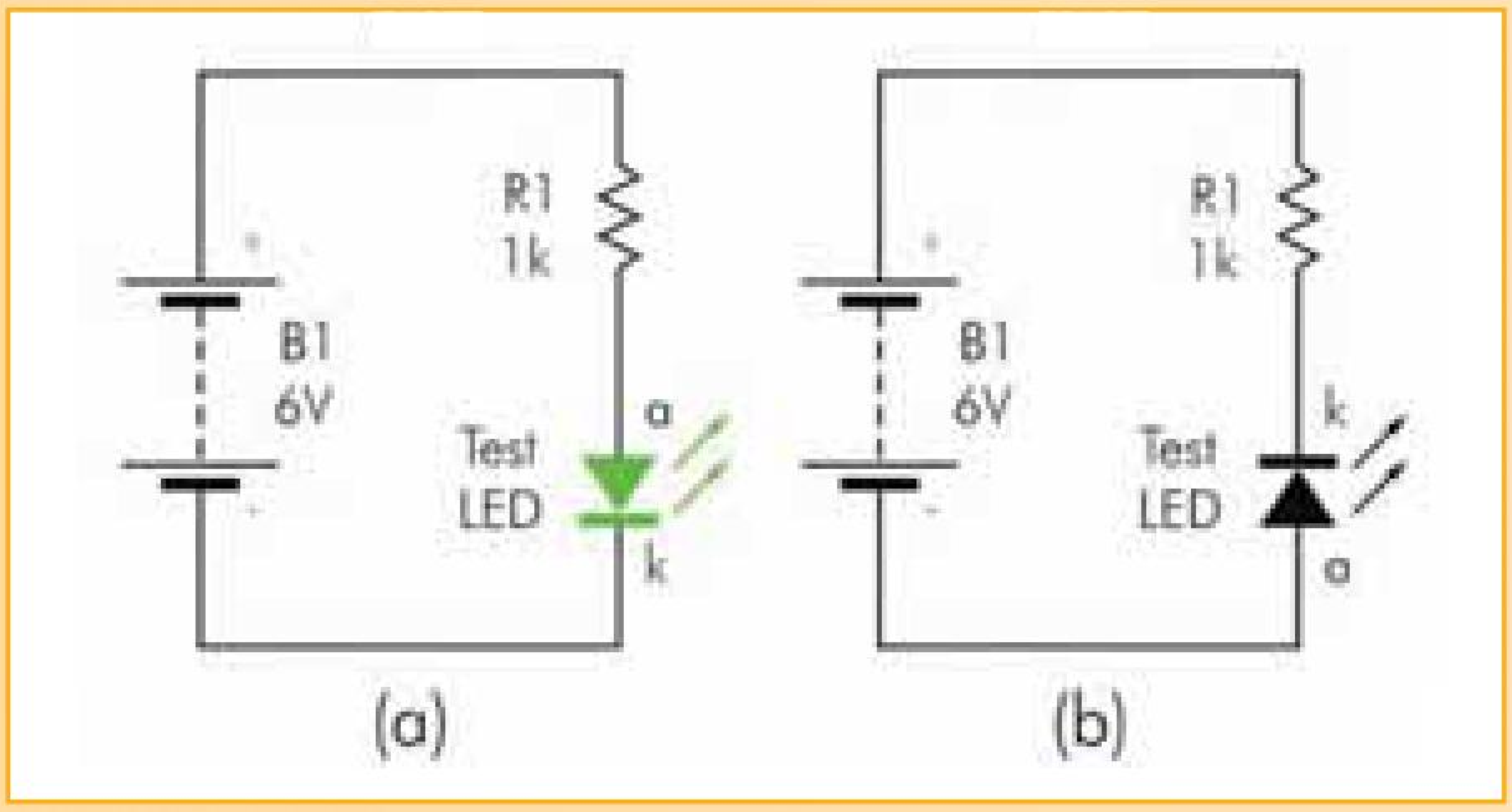


Fig.2. The LED will light up when connected as in (a), but not when it is connected with the polarity shown in (b). The circuit will work with any battery voltage from 3V to 12V

The rest

Zener diodes were once popular for use where a simple voltage regulator circuit was needed, but they are less common in modern electronics. Anyway, they are straightforward to deal with as they normally use the single band method of polarity indication.

Variable capacitance ('varicap') diodes are something of a rarity, but they are sometimes used in radio equipment where they provide an amount of capacitance that is governed by a control voltage. Some of these components look just like ordinary diodes, while others have non-standard encapsulations. With the more unusual types it is necessary to refer to construction diagrams or data sheets for guidance.

Rectifiers are often used in a bridge circuit, which is basically just a ring of four of these components. An AC input signal is applied to two of the leads, and a raw DC output signal is taken from the other two leads. A bridge rectifier can be made from four individual rectifier diodes, but they can also be obtained as single components, containing four rectifiers already connected in the appropriate manner. Thus, these components have four rather than eight leads.

They come in a variety of shapes and sizes, but regardless of the case style they normally have markings that make the correct method of connection very obvious. In some instances, there is a circuit diagram moulded into the case, but the more usual method is to have the AC input leads marked with '~' signs, and the DC output leads marked with '+' and '–' signs (Fig.3).

There is another type of semiconductor that has just two leads, and this is the diac. Although these are sometimes included with diodes in component catalogues, they are not actually a type of diode at all. They are used as trigger devices in power control applications, and they can be connected with either polarity.

Perhaps a little confusingly, some of these components have an encapsulation of the type that tapers at one end, which can give the impression that they are actually polarised. This is not the case though, and they can definitely be fitted either way around.

Polarised capacitors

Resistors and inductors have two leads, but they can be connected with either polarity, as can most types of capacitor. However, *electrolytic* capacitors and certain other high value types such as the *tantalum* variety are polarised, and must be connected with the correct polarity.

High value capacitors are often connected straight across the supply lines of a circuit, and it is likely that a high current will flow through one of these components if it is connected the wrong way around. This usually results in rapid overheating and ultimately the component will almost certainly burst. When fitting high value capacitors it is clearly most important to get it right first time.

Electrolytic and other types of polarised capacitor are normally marked with '+' and (or) '–' signs that make the polarity fairly obvious. The modern trend is for only the '–' sign to be included, and one sign or the other is all that is actually needed. Axial lead electrolytic capacitors additionally have a groove around the body of the component near the positive ('+') lead (Fig.4). Printed circuit mounting electrolytic capacitors often have a similar groove near the base end of the component, but this is of no consequence in the current context.

In the past, it was common for tantalum capacitors to have a system of colour coding to indicate their value and polarity, but this system now seems to be long obsolete. Instead, the value and polarity are normally marked on the body of tantalums in the normal way. This is also the case with other polarised capacitors of the non-electrolytic variety.

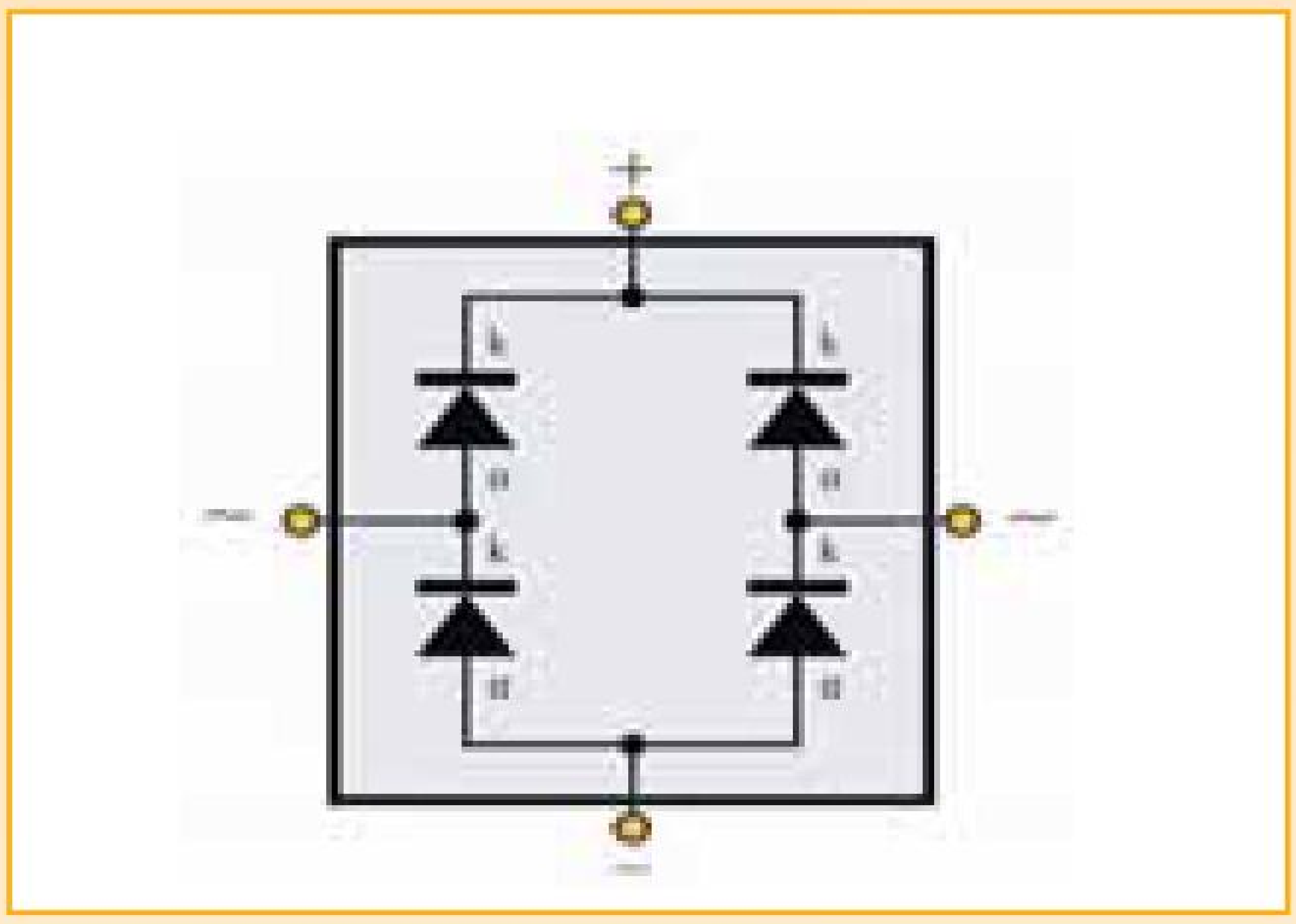


Fig.3. A bridge rectifier is used in power supply circuits to convert an AC input signal to a raw DC output type. The two leads marked with '~' signs are fed with the AC input signal

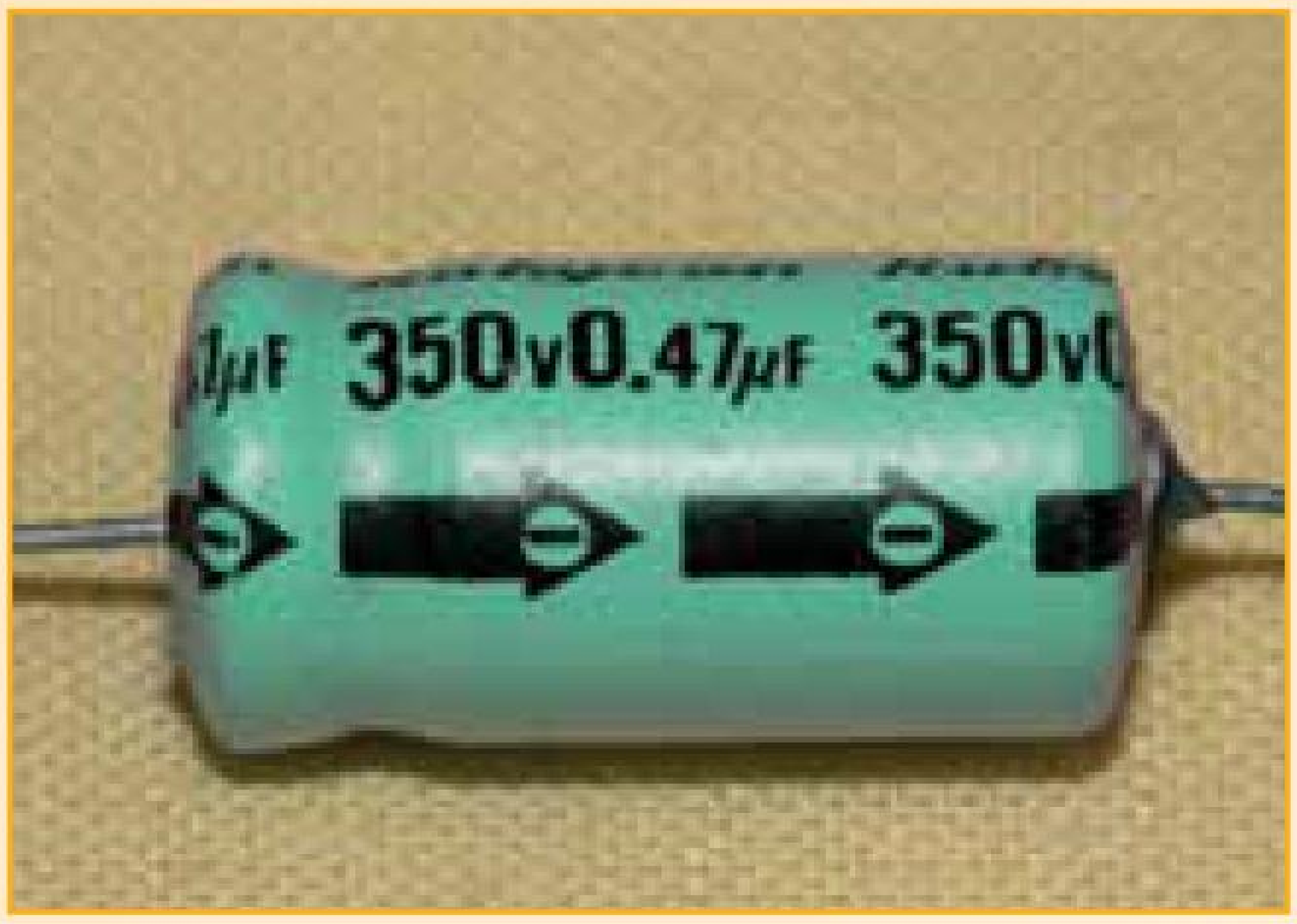


Fig.4. This axial lead electrolytic capacitor has the usual groove around the body near the '+' lead. It also has markings to identify the '–' lead

CIRCUIT SURGERY

REGULAR CLINIC

BY IAN BELL

Digital waveform generation – 3

Two months ago, we looked at a circuit, posted to the *EPE Chat Zone* by contributor ***Agustín Tomás***, which attempted to generate sinewaves digitally. Agustín's circuit suffered from the problem that although it could generate good smooth sinewaves at the upper end of its frequency range, at lower frequencies the output was unacceptably step-like. We described the circuit operation and the basic reason for the problems with Agustín's circuit.

Then last month, we looked at the theory of digital waveform generation in more depth with reference to the block diagram in Fig.1, which is more or less the arrangement used by Agustín. We discussed the spectrum of the sampled signal, and how this lead to a definition of requirements for the low-pass filter. Specifically, the filter must remove all frequencies above the Nyquist frequency (half the sampling frequency). This condition was not met in Agustín's design when he experienced problems with his circuit.

Direct digital synthesis

The approach used in Fig.1 is often referred to as 'direct digital synthesis', or DDS, to contrast with the alternative of using an analogue 'phase-locked loop' (PLL). The PLL frequency may be controlled digitally using a digital frequency divider in the loop, but this is indirect in comparison with DDS, which uses data to represent sample points on the waveform being generated.

The circuit in Fig.1 works well if the filter is correctly designed, but it suffers from the problem that the output waveform frequency, f_o, is directly dependent on the clock frequency f_c. If the sequence generator goes through N steps, for the complete output waveform cycle we have:

$$f_o = f_c/N$$

If we store the waveform data in a memory with n address lines, we can have 2^n samples so $N = 2^n$.

There are a couple of challenges caused by this. First, it is more difficult to create an accurate variable frequency clock than a fixed frequency one, particularly for a wide range with fine frequency control, which is often what is required for a general purpose waveform generator. Even if a variable frequency clock is available, it is likely that it will not be able to change frequency very quickly. This means the frequency generator will not be able to rapidly jump from one frequency to another.

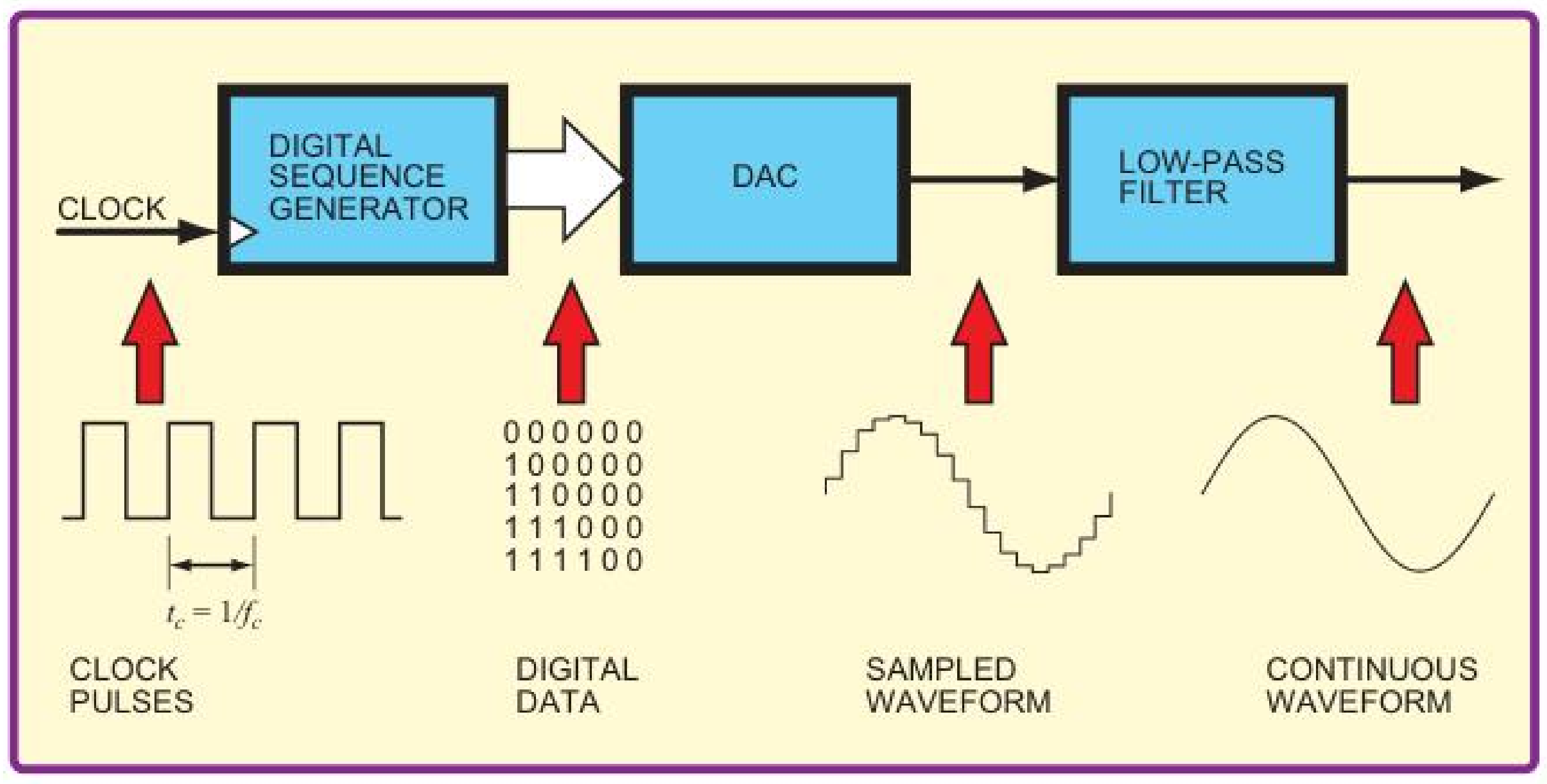


Fig.1. Block diagram of a circuit for digitally generating waveforms

Frequency tracking

Second, changing the clock frequency changes the sampling frequency, f_s. In fact, for Fig.1 the clock and sample frequencies are equal ($f_s = f_c$). The important implication of this is that changing the clock frequency will change the filtering requirements.

As mentioned above, and discussed in more detail last month, the filter must remove all frequencies above half the sampling frequency for the output waveform to be correctly reconstructed from sample data. If the sampling frequency changes the filter cut-off frequency must change accordingly. This was not the case in Agustín's design, hence the problems he experienced.

Designing a filter which correctly tracks the sampling frequency over a wide range is much less straightforward than using a fixed cut-off frequency, and, therefore, undermines the convenience of Fig.1 for digital waveform generation.

The generated frequency can also be changed by reprogramming the sequence generator. Typically, this would involve loading new sample points into a ROM, or other memory; again this could not be done very quickly during operation. In Agustín's case it would be more difficult, as the waveform shape was defined by a set of resistor values (in effect he used a custom DAC characteristic with a fixed digital sequence).

Numerically controlled oscillator

The problem of output frequency being related to clock frequency can be overcome using what is known as a 'numerically controlled oscillator' (NCO). An NCO-based DDS uses a fixed clock frequency and sample rate, and therefore requires a fixed cut-off reconstruction filter. An NCO can also provide very rapid frequency changes in the generated waveform.

In the remainder of this article, we will describe the

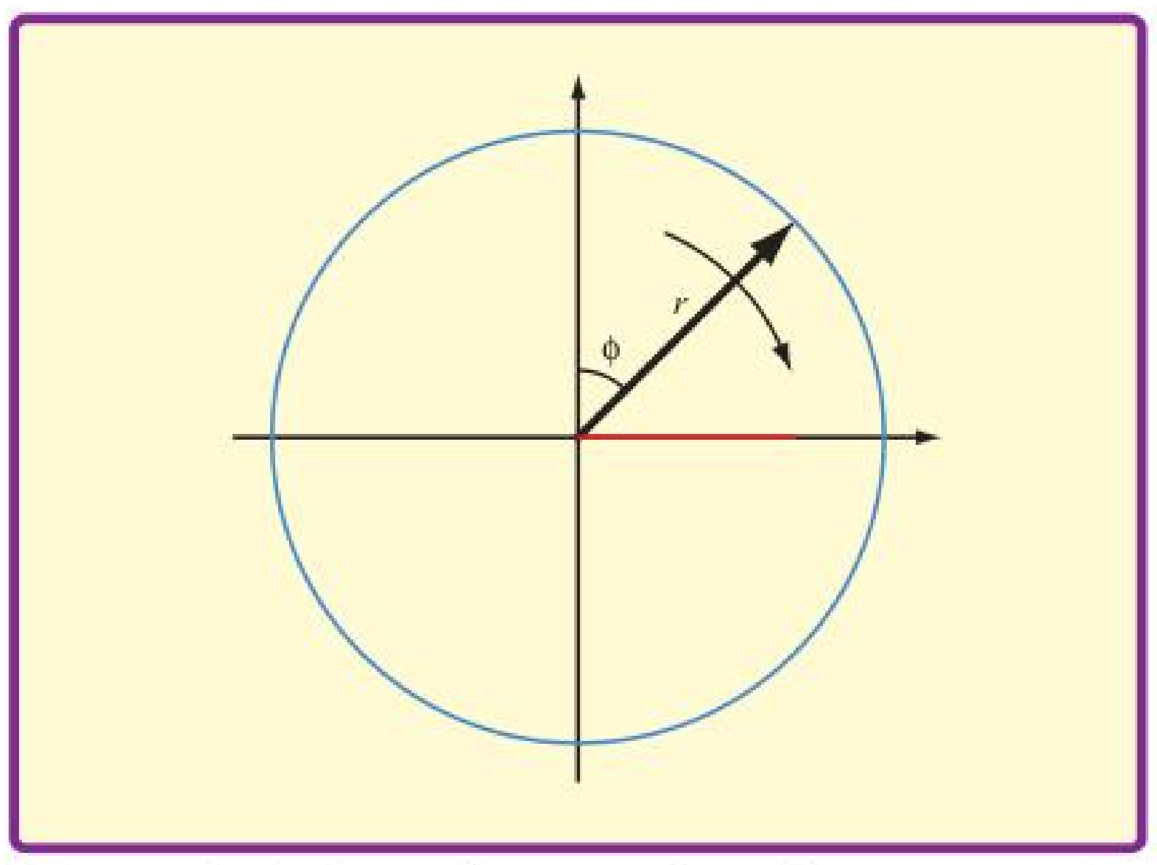


Fig.2. A circle with a radius line sweeping round it like a clock hand

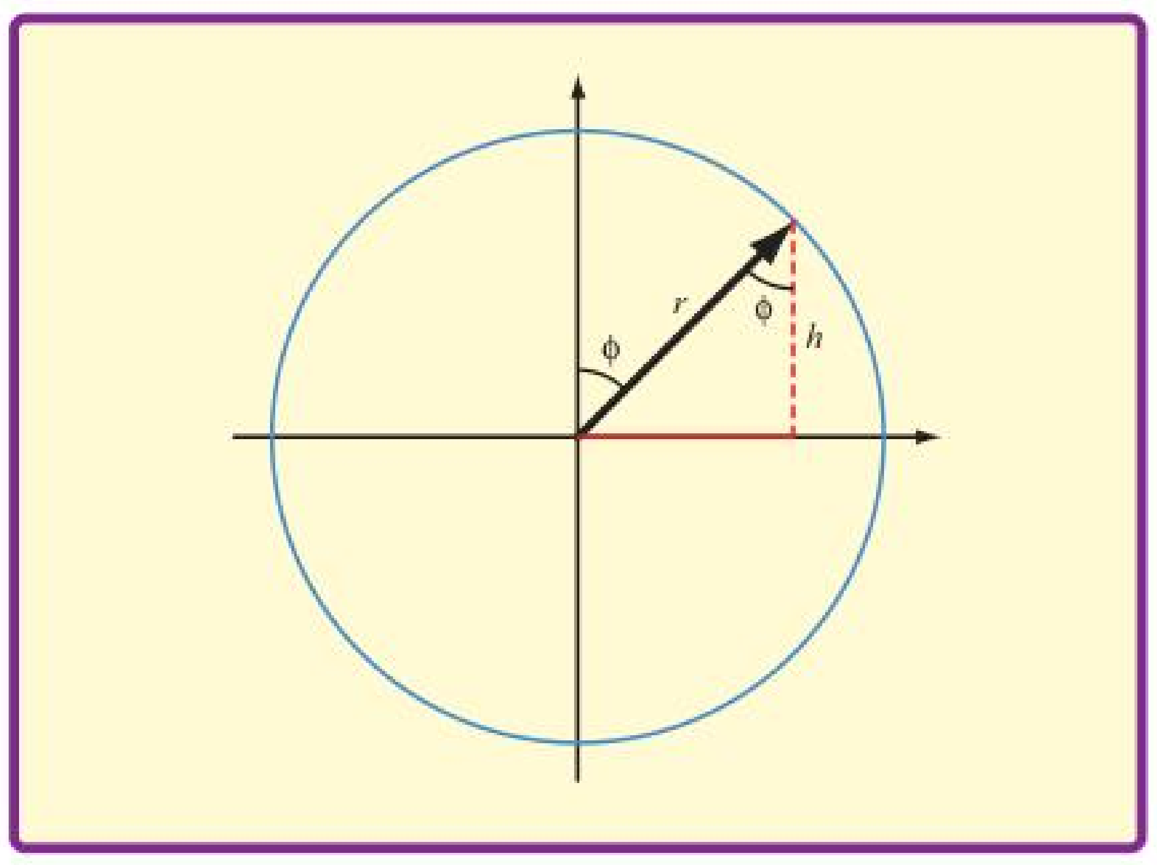


Fig.3. The height, h, *of the radius is a sinewave function*

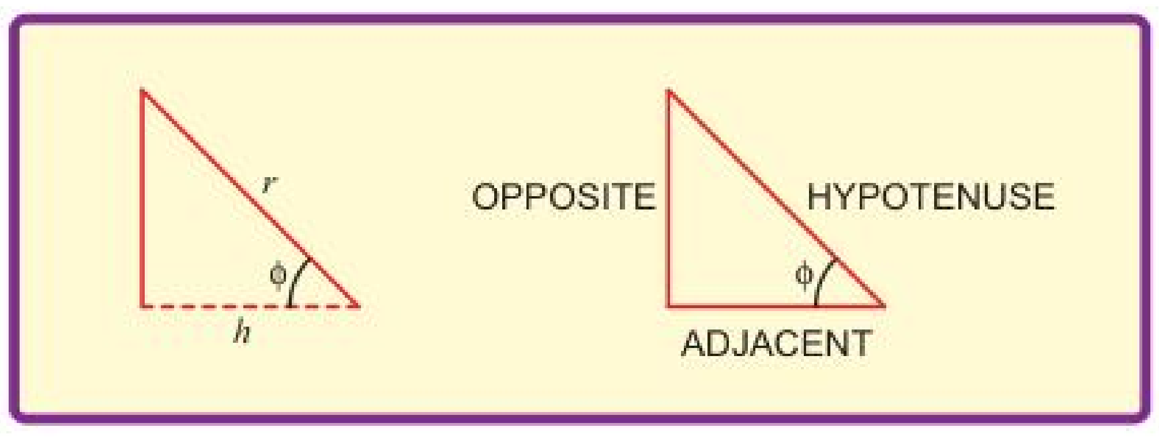


Fig.4. Some basic trigonometry, including standard labelling of triangle edges

basic principles of NCO-based DDS, and also have a quick look at one of the chips that make it easy to build a DDS circuit. We will start our discussion with a bit of basic geometry, as this will help us visualise the way the NCO works.

Circle line

Sinewaves are closely related to circles, and this can help us visualise how we can use stored data to generate sinusoidal (or other) waves of different frequencies. In particular, the sinewave is related to a point sweeping round a circle at constant speed – just like the hand of a clock.

Consider a circle, centred on horizontal and vertical axes, in which we have a line from the centre to the edge, as shown in Fig.2. We can define the position of the line by the angle, ø, from a reference point, such as the vertical axis to the top of the circle. The length of the line is the radius of the circle, r.

We can measure the height, h, of the end of the radius line above the horizontal axis, as shown in Fig.3. The angle between this line and the radius is also ø because the 'height line' is parallel with the vertical axis. The radius, height line and part of the horizontal axis form a triangle which is redrawn (rotated) in Fig.4.

Fig.4 may stir memories of school trigonometry, and indeed that is the point here. Readers may recall that cosine is defined by the length of the *adjacent* divided by the hypotenuse. For our triangle the *hypotenuse* is the radius line and the adjacent is the height line, so we have:

$$cos(\text{ø}) = h/r$$

which on multiplying both sides by r gives:

$$h = r cos(\text{ø})$$

So, if we sweep our radius line around the circle at a constant rate (of change of ø) the above equation shows that the value of h will follow a cosine function (remember r is constant). If we plot a graph of the value of h against ø (or time) as our radius line moves, we will get a cosine or sinewave (depending on our starting reference point).

On the dot

Such a graph is shown in Fig.5, in which each red dot on the circle corresponds to a step in angle of ø. The cosine wave in Fig.5 also has red dots, one for each dot on the circle. These are evenly spaced along the time axis and at the same height as the corresponding dot on the circle. The arrow on Fig.5 shows the link between an example point on the circle and waveform. Of course, we can go round the circle again and again, extending the waveform indefinitely.

It is useful to watch an animation of the circle/sine relationship shown in Fig.5 and there are numerous examples on the web, for example see: **www.youtube.com/watch?v=Ohp6Okk_tww**. A search for 'sinewave circle animation' or similar will provide more examples.

The height (above or below the horizontal axis) of the dots around the circle in Fig.5 corresponds with the data values stored in the sequence generator in the circuit in Fig.1 (the sample values of the sine-wave). The sampling frequency is related to the spacing of the red dots on the waveform in Fig.5; this is also indicated by the dashes at the bottom of the figure.

It is straightforward to change the waveform frequency by changing the sample rate. Fig.6 shows a situation in which the sample rate has been doubled to double the waveform frequency. Exactly the same sample data is used, but at a faster rate. This is how we need to operate the circuit in Fig.1, with the resulting problems we have already discussed.

Skipping

An alternative way to change the waveform frequency is to skip some of the sample points as we go round the circle. For example, we can keep the same sample rate as Fig.5, but only use alternate dots, as shown in Fig.7. This doubles the waveform frequency *without changing the sample rate*. The fact that the sample rate is the same means that we can use the same fixed low-pass filter without degrading the quality of the lower frequency waveforms.

As noted earlier, if we store the waveform data in a memory with n address lines, then we can have a total of 2^n waveform samples in one cycle. If we generate our output using every sample, we get an output frequency of $f_c/2^n$, as with Fig.1 and Fig.5. However, if we skip alternate memory locations the frequency doubles to $2 f_c/2^n$, as in Fig.7.

We can skip more samples to get higher frequencies and, in general, if we move forward M stored samples for each output sample, the output frequency is:

$$f_o = M f_c/2^n$$

This is like moving forward by M dots round the circles in Fig.5 and Fig.7 to get the next value to use. Remember, in this approach the output samples are produced at the same rate irrespective of how far we step to get the next value.

The fact that the output frequency is $M f_c/2^n$ is important, because although it depends on the clock frequency, unlike for the circuit in Fig.1, it is not wholly

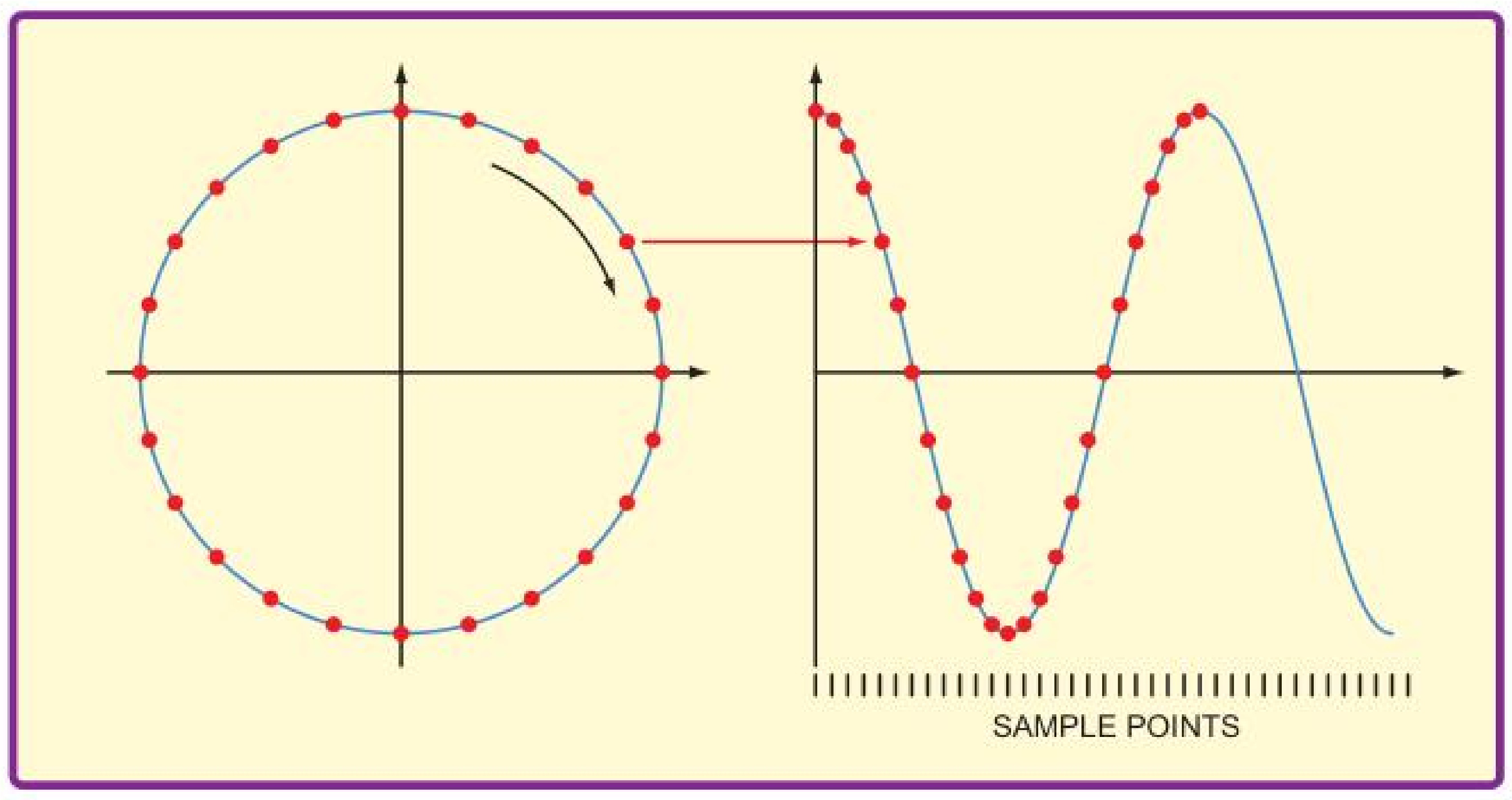


Fig.5 (above). The points on a circle generating a sinewave

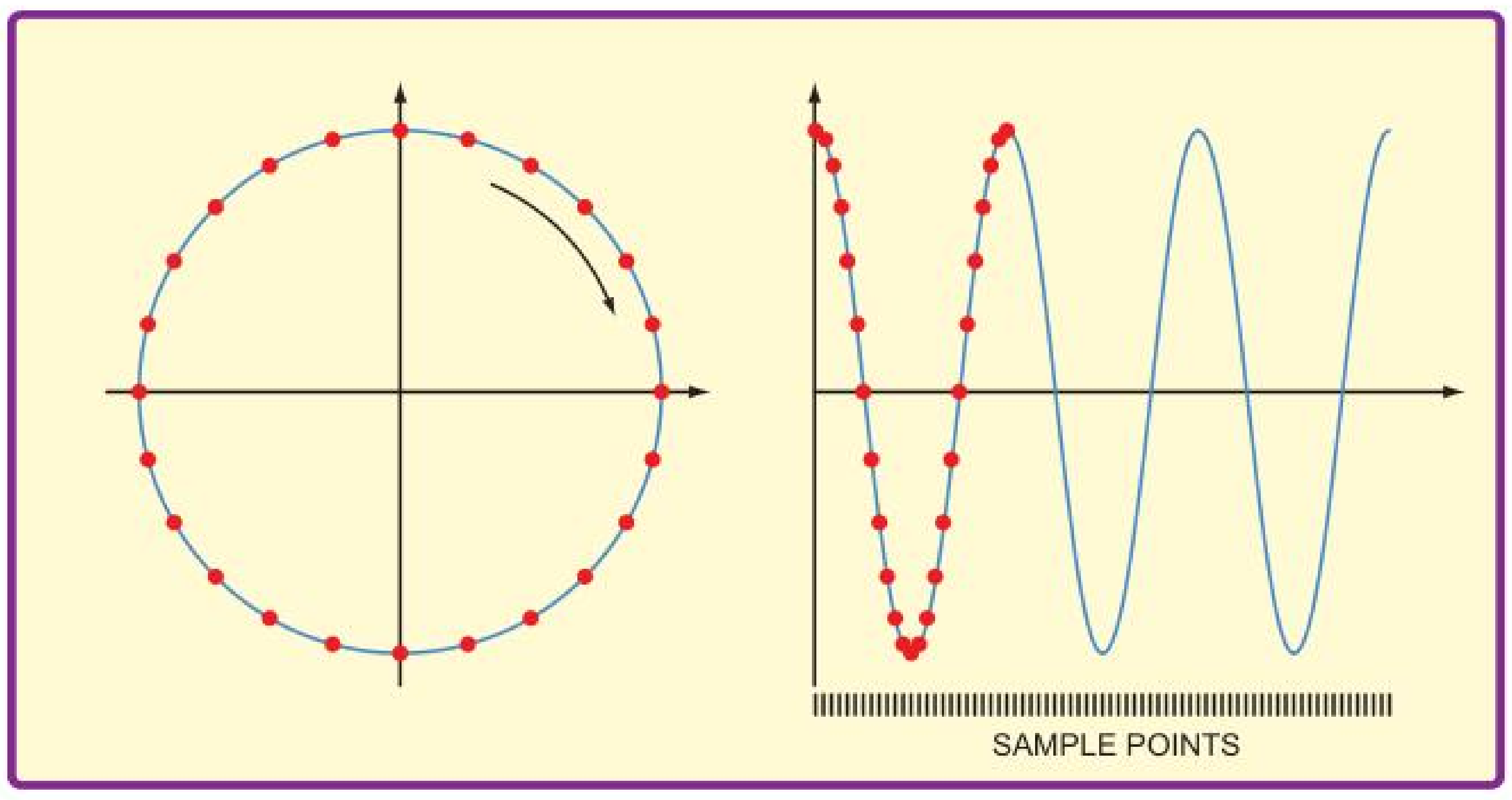


Fig.6 (above right). Using the same sample data at a higher sample rate increases the waveform frequency

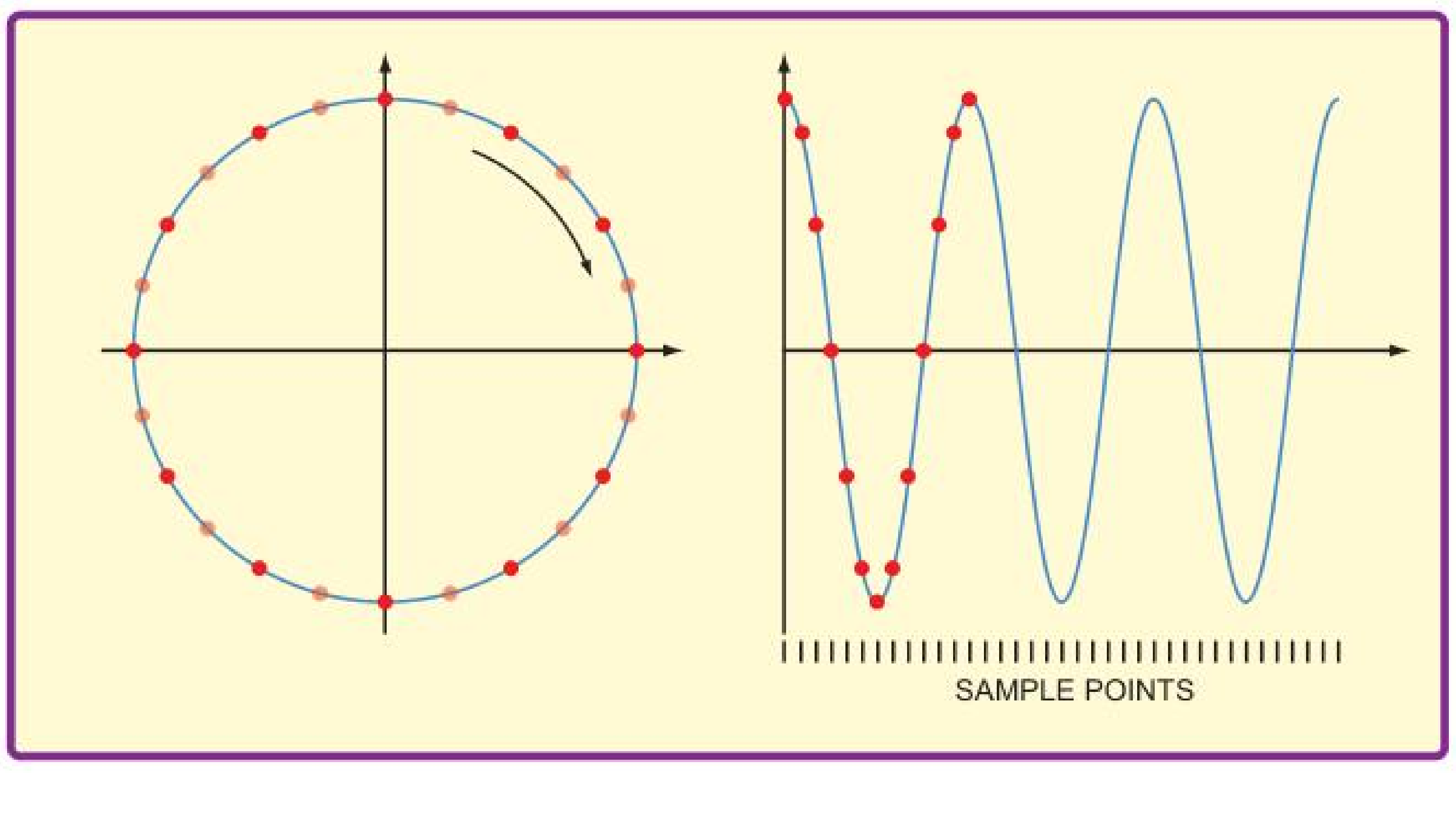


Fig.7 (right). Skipping some of the sample points allows the higher frequency waveform from Fig.6 to be produced using the sample frequency as used in Fig.5 dependent on it. If we can vary *M* in our circuit design we do not have to change f_c to vary the output frequency. We can fix the sample frequency at the clock frequency and therefore use a fixed low-pass filter. We overcome the problems with the circuit in Fig.1.

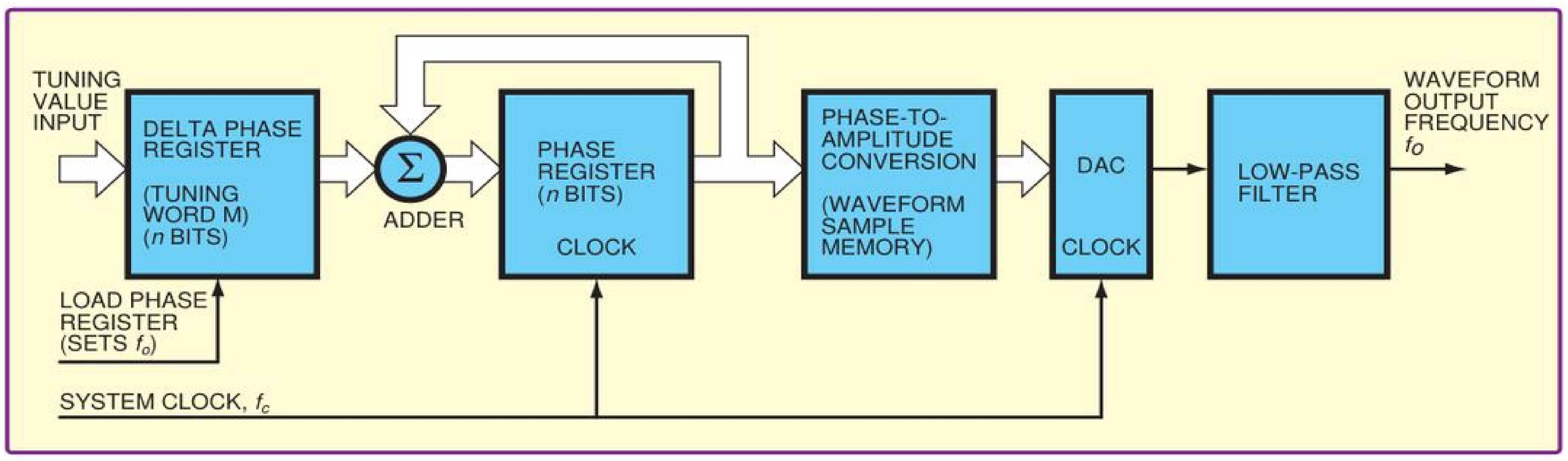

TUNING VALUE INPUT
DELTA PHASE REGISTER (TUNING WORD M) (n BITS)
Σ
ADDER
PHASE REGISTER (n BITS)
CLOCK
PHASE-TO-AMPLITUDE CONVERSION (WAVEFORM SAMPLE MEMORY)
DAC
CLOCK
LOW-PASS FILTER
WAVEFORM OUTPUT FREQUENCY fo
LOAD PHASE REGISTER (SETS fo)
SYSTEM CLOCK, fc

Fig.8. Block diagram of a DDS waveform generator using a numerically controlled oscillator

If we refer back to Fig.2, we see that *M* corresponds to the angle, ø, which we move through to get to the next sample point. This is a phase shift in waveform terms, so *M* is referred to as the 'delta phase value'. *M* is also called the 'tuning value' because it sets the output frequency.

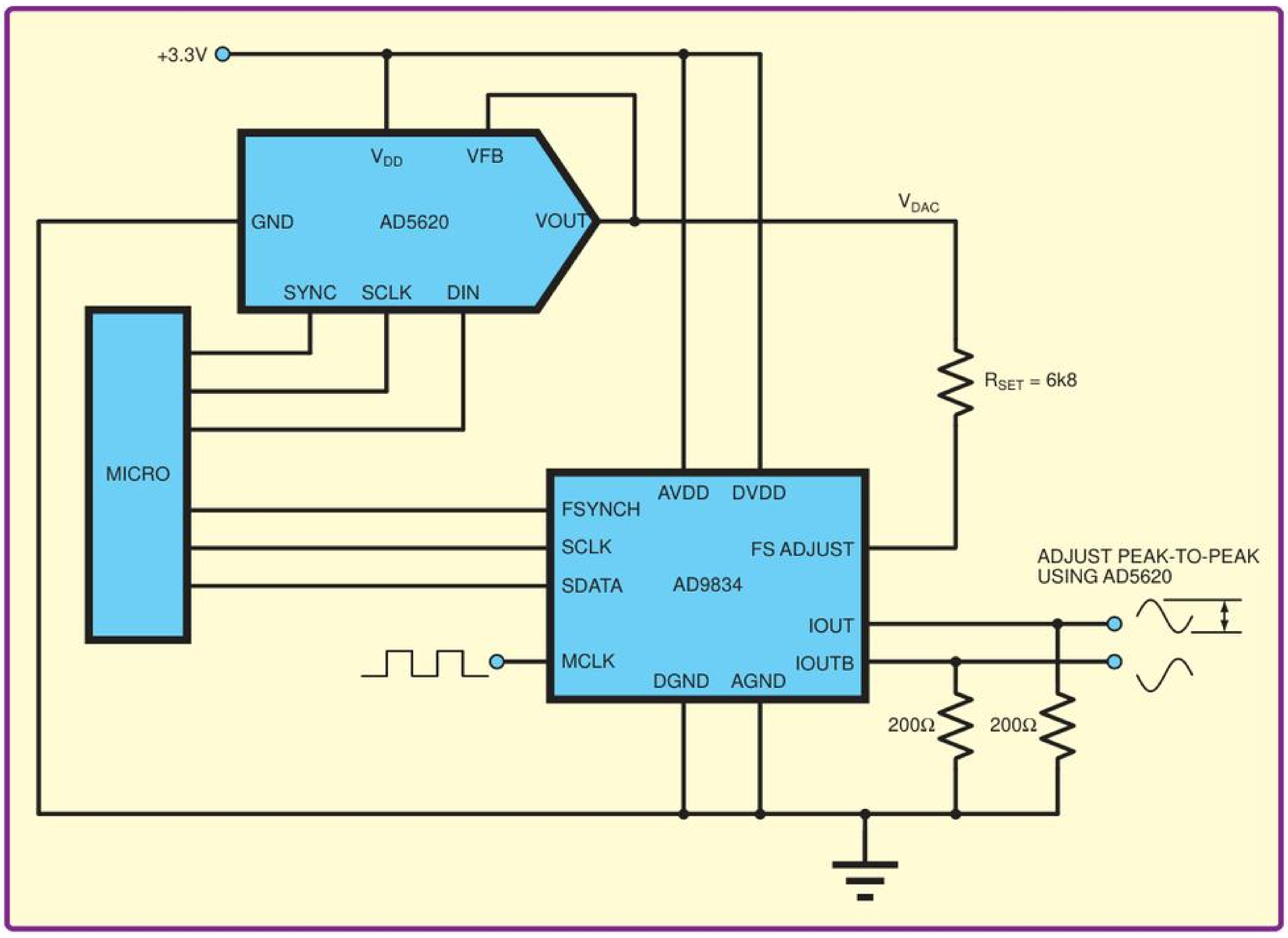


Fig.9. Example DDS circuit using the AD9834. Circuit from Analogue Devices Circuit Note CN-0156

Digital waveform generator

A block diagram of a digital waveform generator, using the principles just outlined, is shown in Fig.8. The value of *M* is loaded into the delta phase register to set the output frequency. For each sample point (system clock cycle) the value in the delta phase register is added to the current waveform location, which is stored in the phase register. In terms of the circles and dots in Fig.5 and Fig.7, the phase register indicates which dot we are currently using for the output sample, and the delta phase register determines how many dots we will go forward to get the next output sample.

The phase register is used to address the waveform sample data memory, converting the phase value to the waveform amplitude at that point of its cycle. This value is passed to a DAC and low-pass filter to convert it to an analogue waveform. Loading a new value of *M* into the delta phase register will change the output frequency immediately on the next system clock cycle. Thus, the frequency can change very quickly and at any point on the waveform cycle.

Looking at Fig.5 and Fig.7, it might seem that the number of possible output frequencies is very limited, that is the frequency resolution is poor. Indeed, this is true for the example presented in Fig.5 and Fig.7, but a real implementation is not limited by the need for a clear diagram and can have many more available sample points (effective dots round the circle).

For a 32-bit phase register, the frequency resolution is one part in four billion. Typical DDS chips use 24 to 32-bit phase registers. In general, frequency resolution is $f_c/2^n$ for a clock frequency of f_c and an *n*-bit phase register.

Other considerations

So far, we have presented a simplified overview of an NCO-based DDS operation. In practice, a number of other details have to be considered. Usually the full number of bits of the phase register is not used to address the sample memory. Truncating the address into the memory adds a small error to the waveform, which appears as noise in the output. Typically, 12 to 19 bits of the 24 to 32-bit phase value are used. The number of bits in the DAC may also be less than the number of bits in the sample memory address (typically 12 to 14-bit DACs are used); again this adds a small error as quantisation noise in the output.

Direct digital synthesis chips

A number of DDS chips are available, particularly from Analogue Devices, and full details of various options can be found on their website (**www.analog.com**). Typically, DDS chips are used in conjunction with a microcontroller, such as a PIC, which is used to control the DDS device via a standard serial bus such as SPI. Fig.9 shows a simplified schematic of a practical DDS circuit from Analogue Devices using an AD9834. The circuit also features a DAC to control the output amplitude. The clock generator for the DDS and the low-pass filter are not shown.

The AD9834 is a low power DDS device, which can generate sine and triangular outputs up to 37.5MHz with a maximum clock speed of 75MHz, but it can be run at much lower clock speeds if desired. The phase register is 28 bits so, for example, with a 1MHz clock the output frequency can be set with 0.004Hz resolution. The AD9834 operates from a supply of 2.3V to 5.5V and has separate analogue and digital supplies, which may be at different voltages. The chip is controlled via a 40MHz SPI bus, which is compatible with a wide range of microcontrollers.

Reference/further reading

Analogue Devices, *Fundamentals of Direct Digital Synthesis (DDS)* – Tutorial MT085 (**www.analog.com/static/imported-files/tutorials/MT-085.pdf**)

Analogue Devices, *Amplitude Control Circuit for AD9834 Waveform Generator (DDS)* – Circuit Note CN-0156 (**www.analog.com/static/imported-files/circuit_notes/CN0156.pdf**)

Analogue Devices AD9834 Data Sheet (**www.analog.com/static/imported-files/data_sheets/AD9834.pdf**)

Max’s Cool Beans

By Max The Magnificent

Beware the forthcoming robot wars

As if I didn’t have enough to worry about… after reading *Robopocalypse* by Daniel Wilson (ISBN-10: 0385533853) I’m now keeping a very wary eye on my new computerised toaster…

Robopocalypse is a hyper-realistic story of a robot uprising set in the not-too-distant future, when robots help to clean our houses, drive our cars, and fight our wars. The problem arises when we create a self-aware sentient artificial intelligence that decides humans are a threat to its existence, so it starts working in the background to take over all of the regular robots until it’s time to strike, at which point it tries to annihilate us.

There are many really good things about this book, not the least that the author has a PhD in robotics from Carnegie Mellon University and he really knows what he’s talking about. Thus, the dozens of unique robots that spy, stalk, and fight through the book are grounded in existing robotic research.

So, just how far-fetched is the book’s scenario? Well, it all depends on who you talk to. In his book *The Singularity is Near*, futurist Ray Kurzweil predicts that we will achieve the equivalent of a single human-level artificial intelligence by around 2020; also that by around 2045, the sum total of robotic intelligence will exceed that of the combined intelligence of every human on the planet (estimated to be close to 9 billion by around 2045).

But, will these artificial intelligences be self-aware to the level that they might decide humans are a threat and determine to remove us from the picture? Some experts believe that this will never happen; other people aren’t so sure. Just the other day I turned on the television and found myself watching one of those ‘Ten Ways the World Might End’ type programmes. You can only imagine my surprise to discover that our being wiped out by self-aware artificial intelligences was rated about number six on the list.

Counting down to the EOTWAWKI

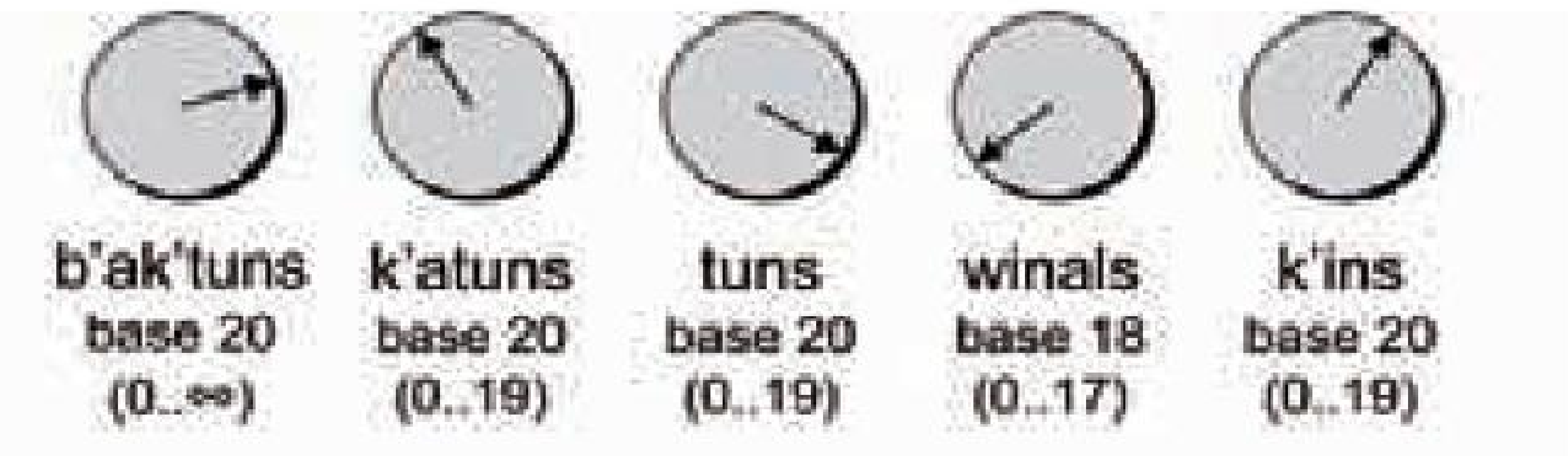
Speaking of the EOTWAWKI (End Of The World As We Know It), or EOTW for short, an increasing number of folks are saying that this is scheduled for 21 December 2012, but what is the basis for this latest EOTW scare?

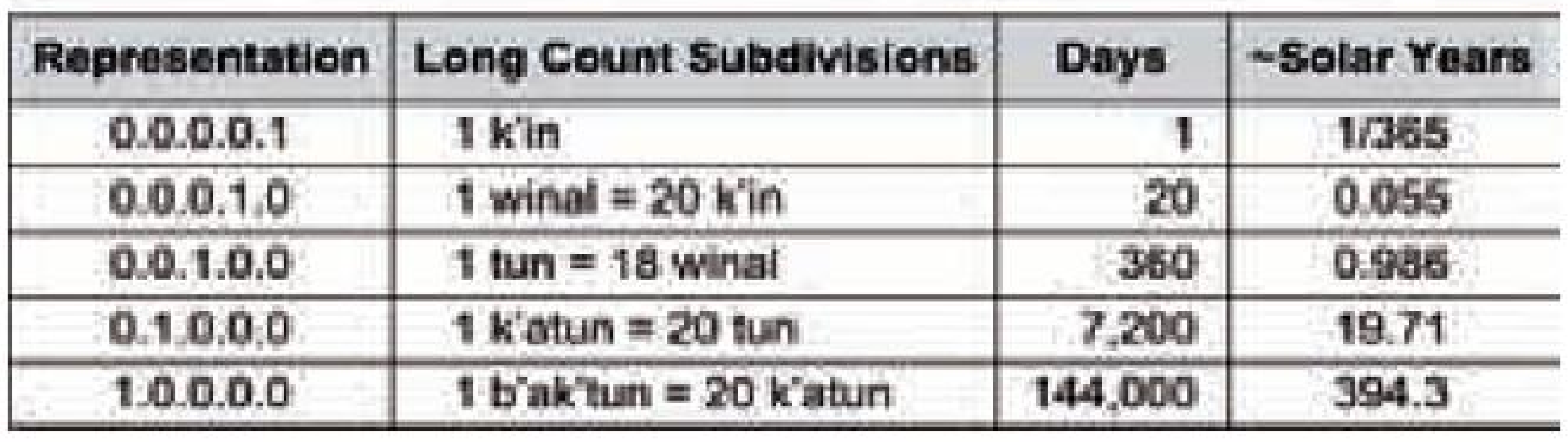
Well, before we start, let’s remind ourselves that predicting the EOTW party-game has not been confined to recent times. For example, many Christians thought that 1 Jan 1000 AD would be the EOTW, and quite a few gave all of their possessions to the Church in anticipation that ‘The End Was Nigh’. And don’t even get me started on the Year 2000 and the Y2K ‘bug’.

But let’s return to 21 December 2012. Why is this date the one that everyone is currently talking about? Well, if you Google ‘2012 End of the World’ you will be presented with all sorts of… let’s say ‘interesting’ information… including stuff like the following example:

According to Mayan Prophecy, the end of the world will happen on the year 2012. The ‘Mayan Doomsday Prophecy’ tells that there will be major disruption on earth. Chaos will happen all over the world, which will lead to the death of millions of living creatures.

The only problem with this is that there never was a Mayan Doomsday Prophecy. What there is, is something called the *Mesoamerican Long Count Calendar*. This calendar was used by several pre-Columbian Mesoamerican cultures, most notably the Maya. For this reason, it is sometimes known as the Maya (or Mayan) long count calendar. One way to visualize this is as a series of dials, each representing a cycle (or digit), with the least-significant digit being on the right-hand-side.





Representation	Long Count Subdivisions	Days	~Solar Years
0.0.0.0.1	1 k'in	1	1/365
0.0.0.1.0	1 winal = 20 k'in	20	0.055
0.0.1.0.0	1 tun = 18 winal	360	0.986
0.1.0.0.0	1 k'atun = 20 tun	7,200	19.71
1.0.0.0.0	1 b'ak'tun = 20 k'atun	144,000	394.3

The five-place notation system of ascending cycles are made up of k’ins (24-hour days), winals (20-day months), tuns (18 winals), k’atuns (20 tuns), and b’ak’tuns (20 k’atuns). A full cycle of the Long Count Calendar involves thirteen b’ak’tuns, which equates to 5126 years.

The current cycle commenced on 11 August, 3114 BC, as measured by the modern Western/Gregorian calendar. As a simple example, the signing of the US Constitution took place on 4 July 1776, which equates to 12.8.0.1.13 in the Long Count Calendar.

The end of the current Long Count Cycle will occur on 12.19.19.17.19, which equates to 20 December 2012. This will be followed by the start of the next cycle, which commences with the first day of the 14th b’ak’tun on 13.0.0.0.0, which equates to 21 December 2012.

But the real point is that the Maya did not regard the end of the current Long Count Cycle as being the EOTWAWKI; instead, they predicted a number of things happening in the next cycle. The problem, of course, is that all sorts of ‘slime-balls’ will be crawling out of the woodwork instigating all sorts of FUD (fear, uncertainty, and doubt), with the ultimate aim of trying to get us to part with our hard-earned money.

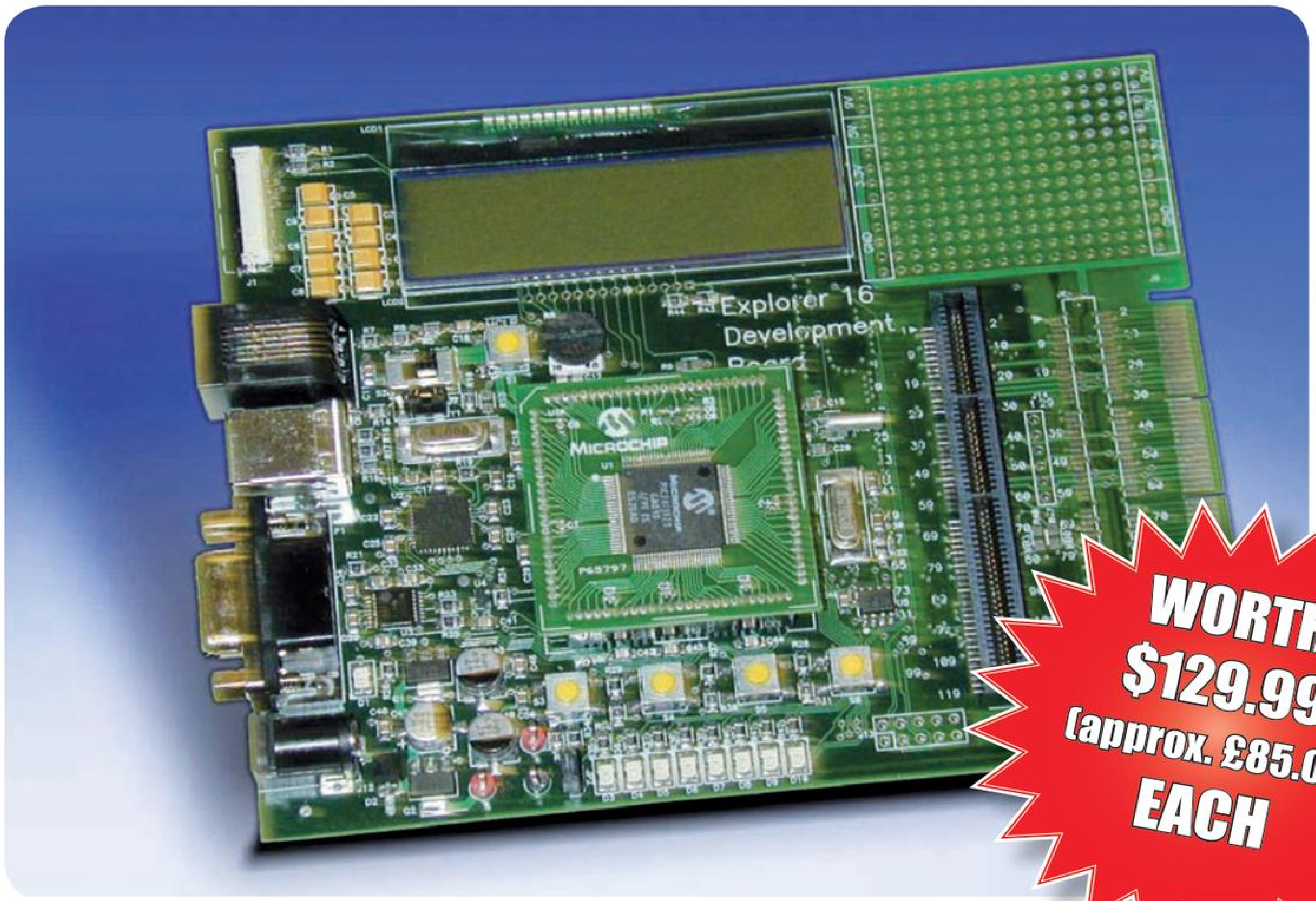
In the coming months, we can expect to be assaulted with offers for EOTW survival kits of dubious value and all sorts of other weird and wacky things. So, until next time (or the EOTWAWKI – whichever comes first), have a good one!

EPE EXCLUSIVE

Win a Microchip 16-bit Explorer Board

EVERYDAY PRACTICAL ELECTRONICS is offering you the chance to win a Microchip 16-bit Explorer Board. The Explorer 16 is a low-cost, efficient development board to evaluate the features and performance of Microchip's new 16-bit PIC24 Microcontroller and dsPIC33 Digital Signal Controller (DSC) families. Coupled with the MPLAB ICD 2 In Circuit Debugger, real-time emulation and debug facilities speed evaluation and prototyping of application circuitry. The Explorer 16 features two interchangeable Plug-In Modules (PIMs), one each for the PIC24FJ128GA010 and the dsPIC33F128GP710 DSC.

It features both PIC24FJ128GA010 Microcontroller and dsPIC33F128GP710 Digital Signal Controller PIMs, an alphanumeric 16 × 2 LCD display and interfaces to MPLAB ICD 2, USB, and RS-232. It includes Microchip's TC1047A high accuracy, analogue output temperature sensor, an expansion connector to access full devices pin-out and a bread board prototyping area and a PICtail Plus connector for future expansion boards. The full documentation CD includes user's guide, schematics, and PWB layout.



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For the chance to win an Explorer Board, go to: **www.microchip-comps.com/epe-explorer** and enter your details in the online entry form

CLOSING DATE

The closing date for this offer is 30 April 2012

PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

Microchip Arduino platform

THIS month, we take a look at a new range of development boards from Microchip, the ChipKIT platform. What makes these boards of particular interest is they are Arduino compatible, both at the software and hardware level – only an awful lot faster and cheaper.

Arduino

Arduino is an interesting concept with a complicated history. It started life as a project to enable students to build interactive or animated projects without the need to grasp the complexities of electronic design or low level programming. It consists of a small PCB holding an Atmel 8-bit microcontroller and an integrated development environment (IDE) in which programs can be written and quickly downloaded to the board through a serial link. The development environment include a large number of library functions designed to simplify the control of common external devices, such as servo motors, analogue-to-digital converters, displays, SDMedia cards and others.

The programming language used is called *Wiring*. It's based on another language called *Processing*, which itself was influenced by an MIT Media Lab project in the 1990s called *Design By Numbers*. All of these languages are attempts to make computer programming accessible to non-technical designers and artists. Wiring, and the Arduino hardware platform that it runs on, certainly appears to have been a success – over 300,000 Arduino platforms have been sold or built by users around the world, and its popularity appears to be still growing.

That's not to say that Arduino doesn't have its detractors. Some people feel that learning to program should be difficult, because microcontrollers are complicated, and that taking shortcuts will give only the illusion of competency. While that opinion can be laughed off, a more valid criticism is the limitation and cost of the platform.

The board holds a small 8-bit processor running at 16MHz, with few peripherals beyond a timer and a serial port. With it's 0.1in. header strips, it's possible to build circuits without even soldering – just push bare wires into the headers and you're on your way. However, this comes at a relatively high cost. An Arduino board may cost £25, when the equivalent processor may be only a few pounds. It's hard to justify that cost if you're building several projects. And then there's the issue of the processor clock speed...

I feel the need

As Tom Cruise once said: 'I feel the need... the need for speed!' An 8-bit, 16MHz processor in this day and age is not going to take you very far. And this is where Microchip's offering starts to become interesting – they are using the 32-bit, 80MHz PIC32 processor. A great chip with lots of interesting peripherals, but a devil to solder. The chipKIT offers a fast, relatively low cost platform, with easy-to-use interfaces and a very simple-to-use programming environment (not forgetting that the PIC32 is quite a complex processor to setup, software wise.)

Before we look at the ChipKit boards and features, it's useful to view them in perspective with similar boards currently available on the market. We've summarised them in Fig.1.

BOARD	COST (£)	CPU	SPEED (MHz)	FLASH (KB)	RAM (KB)	FEATURES
Chipkit Max32	35	32bit PIC32MX795F512L	80	512	128	On-board 100MB Ethernet MAC, USB Host controller. Arduino compatible.
Chipkit Uno32	19	32bit PIC32MX320F128H	80	128	32	USB Host controller Arduino compatible.
Arduino Uno	18	8bit ATMEGA328	16	32	2	Main Arduino platform
Arduino Mega	46	8bit ATMEGA2560	16	256	8	Main Arduino platform (higher spec.)
Olimex Pinguino-Micro	12	32bit PIC32MX440F256H	80	256	32	USB Host. Simple 0.1" header, breadboard compatible. Arduino like IDE, programming in C MicroSD connector
Pic32 Starter Kit	32	32bit PIC32MX795F512L	80	512	128	32 bit processor. Specialised I/O header, requires high-tech soldering or expensive daughter board.

Fig.1. Comparision of Development Boards

The Arduino platform is available in two variants. The Uno is a physically smaller board with fewer I/O pins available, and much less memory. The Arduino Mega uses a larger Atmel AVR processor, which means more I/O pins are available, and consequently the board is larger than the Uno (although the Uno's I/O connector layout is duplicated, so Uno expansion boards will work with the Mega too.) There is significantly more program and data memory available too, but it's still a slow 8-bit processor.

Now look at the chipKIT versions. Like the true Arduino, they are offered in two formats, the Uno32 and the Max32, matching the I/O connection layout of the Arduino platforms. As we've already mentioned the processor speed is five times faster than the Arduino, plus it's a 32 rather than an 8-bit processor. What does that mean? All operations on data, such as addition, multiplication, conditional tests etc operate on 32-bit wide variables rather than 8-bit wide ones. So if you are adding '1' to a long integer, it will take one instruction on the PIC32 processor, but between four and eight instructions on the already slower AVR processor.

The biggest surprise, however, is the price. Despite being much faster, having more peripherals and more memory, the chipKIT boards are cheaper than the Arduinos. The Uno32, in particular, at just £19, is a very low cost means of gaining experience of the PIC32 processor.

We've listed two other boards in Fig.1. The PIC32 Starter Kit is an example of the (until now) normal means of evaluating the PIC32 processor. It's a compact board at a reasonably comparable price to the Max32, but has no accessible I/O – all of the processor pins are routed to a pair of complex fine pitched connectors. If you want to actually connect anything to the chip, you will have to purchase an equally expensive expansion board, taking that solution beyond the budgets of many hobbyists.

The cheapest readily available board we have found is the Pinguion-micro, available from one of our favorite board suppliers, Olimex of Bulgaria. Although the I/O pin connections are not Arduino compatible, they are routed to 0.1in. pitch header pins, which makes using the board simple. And work is going on in the open-source community to provide an Arduino development environment for it, so at £12 (plus shipping) it looks like a good deal.

We should point out that there are dozens of 'Arduino like' boards available around the world, driven by it's popularity and the open source nature of the design – even copying the design directly, making your own board and offering them for sale is perfectly acceptable. (Don't expect to make your fortunate though – margins on hardware are slim, and manufacturing prices fall only with large volumes.)

So now let's take a closer look at the Microchip offering.

chipKIT

First, these are not a Microchip product *per se*, but are in fact from Digilent, a North American company, known for producing FPGA and microcontroller development boards. Digilent have not only produced the boards, but more importantly created a new version of the Arduino IDE to support the PIC32 processor, including the supporting libraries. This is available to download for free from their website. We will cover the use of the IDE next month.

Digilent currently offer four boards in the chipKIT range, as shown in Fig.2. As well as the two flavours of the control board, there are two adaptor boards (called 'shields' by the Arduino community.) The Network Shield is a Max32 – specific ethernet interface. It contains a 100Mb/s high speed physical interface chip to interface with the PIC32's interface 100Mb/s ethernet media access controller. It also provides a USB device and USB host interface, connecting to peripherals within the PIC32. It's not cheap at £35 plus VAT, but would be attractive if the more common but rather pedestrian ENC28J60 interface is too slow for you.

The Basic I/O shield is a strange mix of graphic OLED display, open drain I/O terminals, pushbuttons, switches, temperature sensor and LEDs. At £24 plus VAT it's unlikely to find its way into a hobby project, but it would serve well in a student class on programming microcontrollers.

The Max32 and Uno32 have holes for mounting the board inside an enclosure, and a power supply bypass jumper, which means you can power the board from the USB interface, a 7V to 12V power brick or batteries, a welcome option for portable operation. Five other headers allow for selection of I/O pin interface modes.

Digilent tell us that both processor boards will work with the existing Arduino shields (of which there are many, many types available) but, not all have been tested. If you intend to connect up a shield that has not been verified as working, you may find that you have to write custom software to support it, rather than relying on a supplied library. As we don't have access to any Arduino shields we have been unable to test this point.

Programming

User programs are downloaded to the board's pre-loaded bootloader via the USB interface, which can then be configured as a serial interface for your own application if you wish. A six-pin header allows access for direct programming of the processor if you prefer to ignore the Arduino interface and work instead with a PicKit2, MPLAB and C32. The compilation and download process with Arduino is fast and easy, making debugging fun, which is handy, as there is no debugger as such within the IDE, so you are very much on your own. Expect to be sprinkling lots of print statements!

So what does this new programming language 'Wiring' look like?

As the language has been designed for ease of learning by non-engineers, one would have thought that it would be somewhat BASIC like, but actually its syntax (the way in which the words are written) is very much like 'C' or even 'C++'. In fact, it's hard to tell if there *is* a difference. An example program is shown in Fig.3. This was our first program written just an hour after downloading the IDE from the Internet.

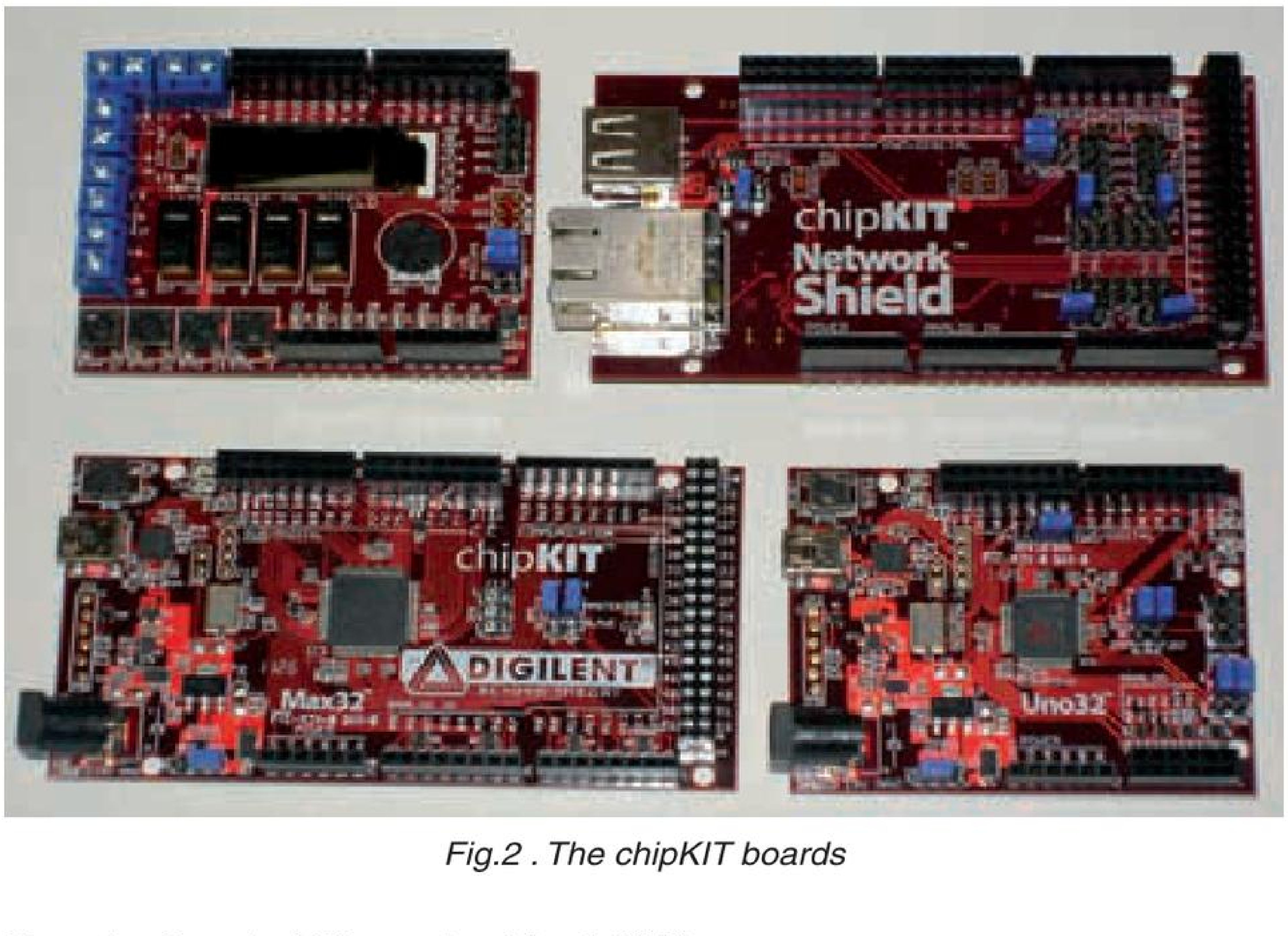


Fig.2 . The chipKIT boards

Programs (or 'Sketches' as the Arduino community like to call them) consist of two main blocks – the 'setup' block and the 'loop'. The former is for the initialisation code that runs once at start-up, and the latter is executed continuous like, unsurprisingly, a loop. While we will defer discussing the details of the language until next month, a short explanation of what this program does will help demystify the language (unless you are already familar with C or C++, in which case you will be wondering why the language isn't called C++!)

The program is intended to flash an LED attached to I/O pin 13 when a GPS module, attached to the serial interface, has locked onto the GPS network. The GPS unit outputs serial messages once a second, one of which starts with the text 'GPGGA'. Embedded within the line containing that text is a single character, which represents whether the module has lock – a '0' means no, '1' means yes. While the program is waiting for the GPS module to get locked, it pulses the LED once every 10s.

Fig.3 is the complete source code, knocked-up in 30 minutes. You can see how easy it is to get going; you do not need to worry about configuring the processor clock speed or operating mode, that is all done for you. Setting up the serial port for 4800 baud reception is achieved with the single command:

```
Serial.begin(4800);
```

As you can see, the 'Wiring' environment, once you understand the basics of the language, removes much of the underlying processor complexity from the user, and leaves them to deal with the complexity they can deal with – the actual problem they are trying to solve.

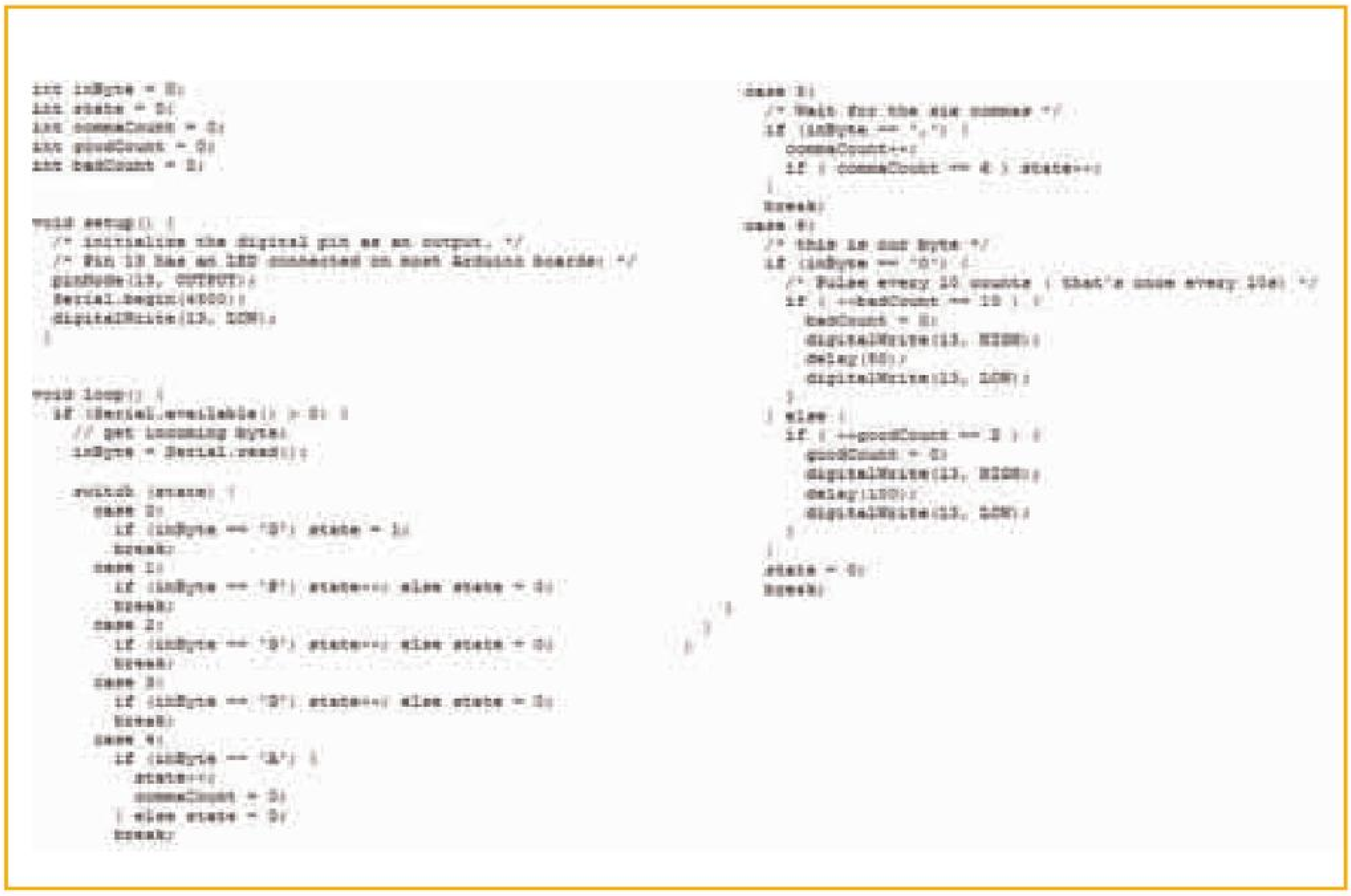
In Summary

Comparing all these boards is complicated, but it is clear that the Uno32 board is very good value for money.

It's our view that with their low price, versatility, ease of use and sensibly positioned headers, these boards will make ideal controllers that could be plugged into your own DIY adaptor board. To test this theory, we will use the Uno32 as the basis for completing our 'Internet Computer' article series, designing a shield holding an SDMedia socket, parallax processor, keyboard, mouse, VGA and Ethernet interface. Watch this space!

The PIC32 is a lovely chip but, with such fine pin pitch, it is difficult to solder, even for the experts. Simple breakout boards pre-fitted with a processor are available, but as these cost almost as much as the Uno32, it's hard to see how the Uno32 could not be an attractive option.

Using the PIC32-specific Arduino environment supplied by Digilent is very easy and quick to learn, so long as the more complex features of the processor, such as interrupts, are not required. When this happens you are on your own, and you will need to resort to writing your own drivers, which rather negates the use of the Arduino environment in the first place. This should



```
int inByte = 0;
int state = 0;
int commaCount = 0;
int goodCount = 0;
int badCount = 0;


void setup() {
  /* initialize the digital pin as an output. */
  /* Pin 13 has an LED connected on most Arduino boards: */
  pinMode(13, OUTPUT);
  Serial.begin(4800);
  digitalWrite(13, LOW);
 }


void loop() {
  if (Serial.available() > 0) {
    // get incoming byte:
    inByte = Serial.read();

    switch (state) {
      case 0:
        if (inByte == 'G') state = 1;
        break;
      case 1:
        if (inByte == 'P') state++; else state = 0;
        break;
      case 2:
        if (inByte == 'G') state++; else state = 0;
        break;
      case 3:
        if (inByte == 'G') state++; else state = 0;
        break;
      case 4:
        if (inByte == 'A') {
          state++;
          commaCount = 0;
        } else state = 0;
        break;
      case 5:
        /* Wait for the six commas */
        if (inByte == ',') {
          commaCount++;
          if ( commaCount == 6 ) state++;
        }
        break;
      case 6:
        /* this is our byte */
        if (inByte == '0') {
          /* Pulse every 10 counts ( that's once every 10s) */
          if ( ++badCount == 10 ) {
            badCount = 0;
            digitalWrite(13, HIGH);
            delay(50);
            digitalWrite(13, LOW);
          }
        } else {
          if ( ++goodCount == 2 ) {
            goodCount = 0;
            digitalWrite(13, HIGH);
            delay(100);
            digitalWrite(13, LOW);
          }
        }
        state = 0;
        break;
    }
  }
}
```

Fig.3. An example sketch

change as Digilent and the community at large provide more software functionality and example programs.

The simple write-download-run approach to software development offered by the IDE is very pleasant, and with the inclusion of a PicKit programming header, there is nothing to stop you abandoning the Arduino approach altogether and simply resort to using MPLAB and the C32 compiler. For us, this is what makes the low priced Uno32 product so attractive, and you can still hook-up any of the existing Arduino shields. If the Arduino shield interface is not a concern for you – for example, if you will build your own interface PCB – then the Olimex PIC32 Pinguino micro is probably a more suitable option for you.

Next month, we will take a look at the IDE, the range of libraries currently available and get to grips with the programming language with a simple GPS module project. The soldering iron, for now, can stay in the cupboard!

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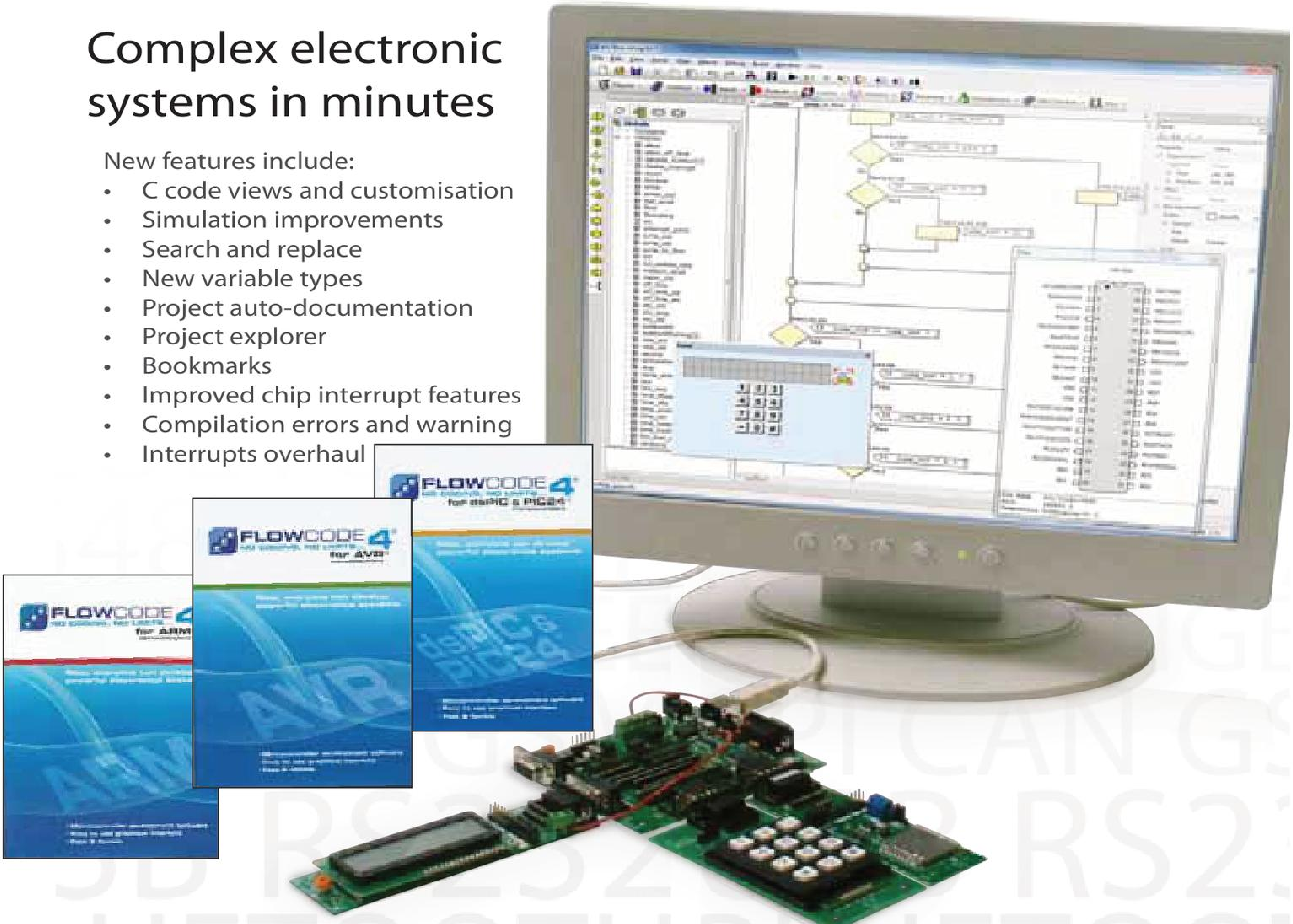

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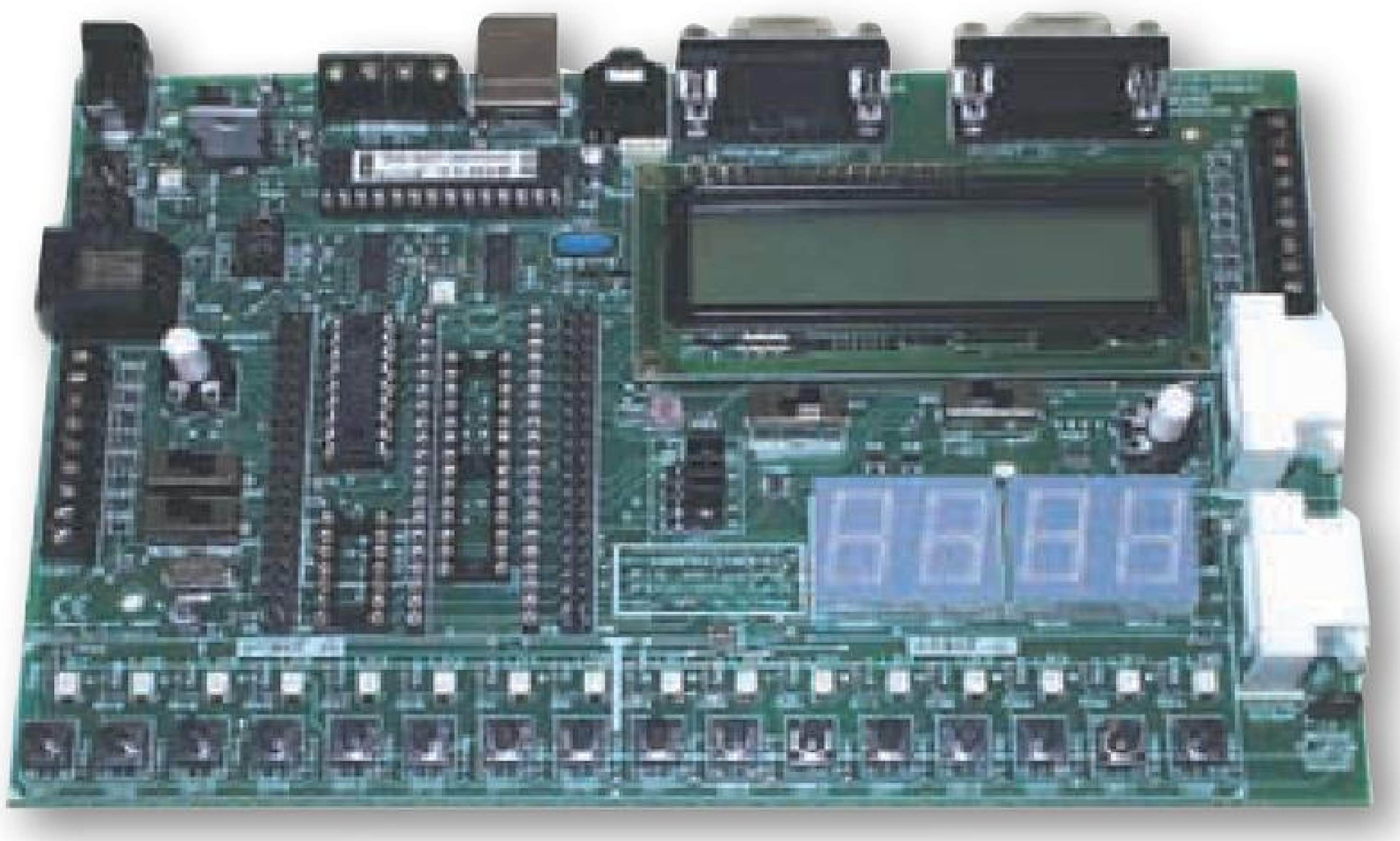

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SOFTWARE

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(Formerly PICtutor)

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The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller, this is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed, which enhances understanding.

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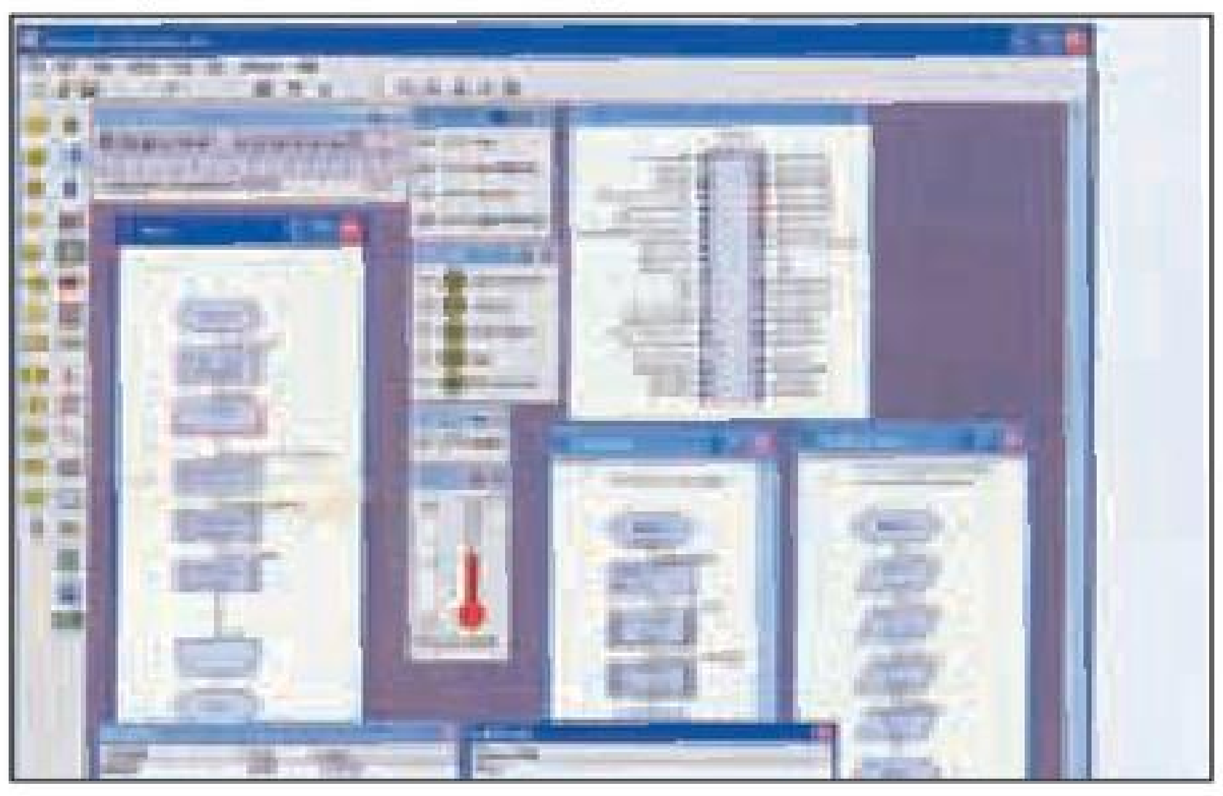

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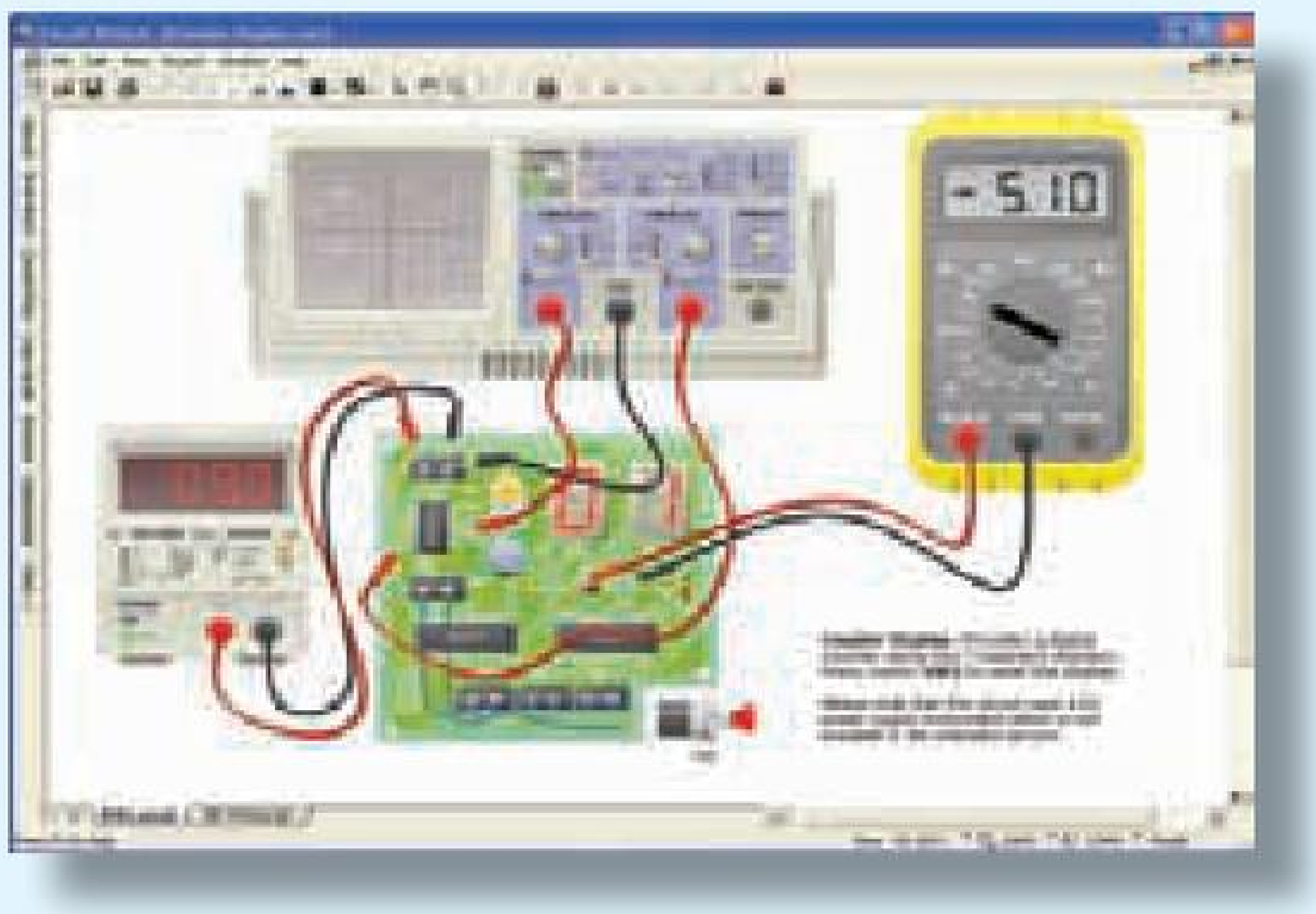

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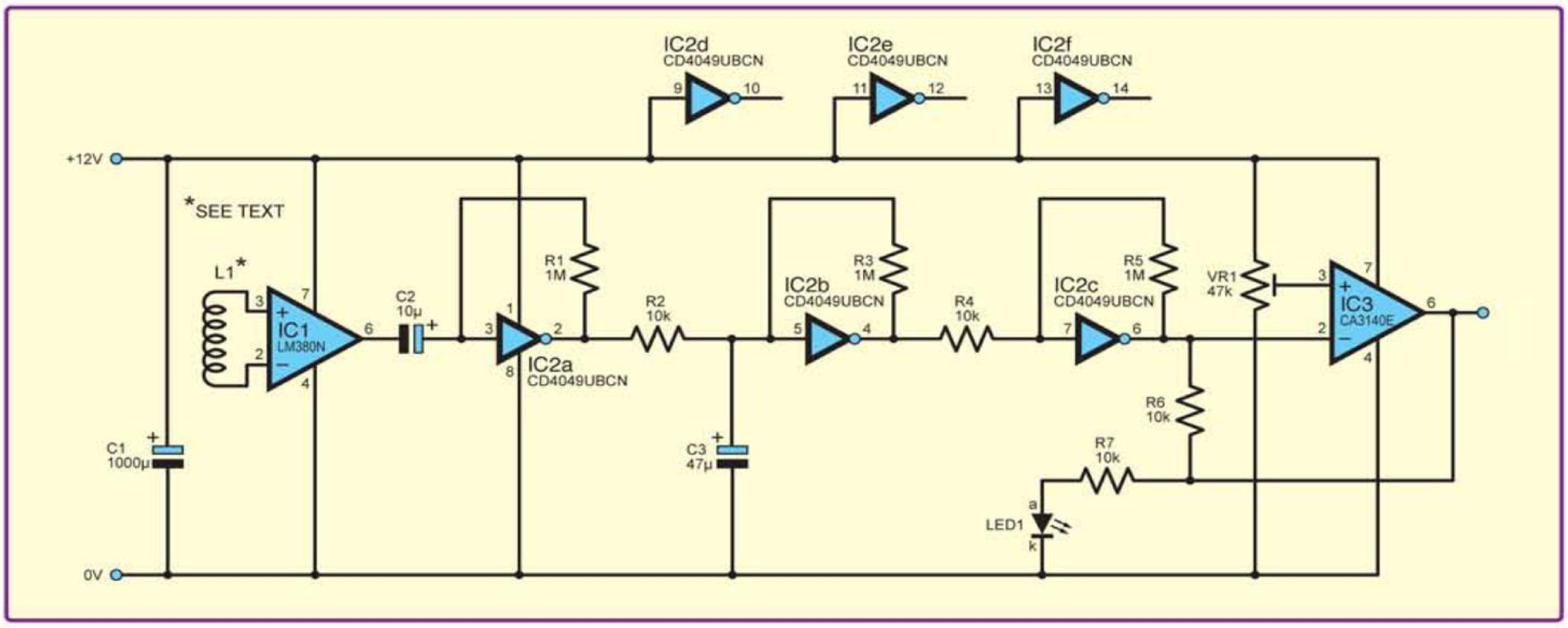

Fig.1. Circuit diagram for an LCR Beat Balance Metal Detector

THE aim of this design was to create a magnetometer which would be optimised for the detection of rotation within the earth's magnetic field – hence the name 'Earth Magnetometer'.

The strength of the earth's magnetic field is typically about 0.5% to 1% of the strength of a fridge magnet. In the author's home town, Cape Town, its strength lies around 26,000nT (nanotesla), while in London it is about 49,000nT. In order to detect this, two things are required. First, a high gain amplifier – for which the combination of IC1 to IC3 provides a gain of well over one-million (see Fig.1). Second, a low-pass filter – for which IC2b filters out almost all but sub-one-hertz fluctuations.

Detection is by means of LED1 – that is, the output of IC3 goes 'high' when rotation of the circuit within the earth's magnetic field is detected. In Cape Town, the circuit detected a slow (6 to 60rpm) rotation of the earth's magnetic field. This slow rotational speed was chosen in order to exclude spurious triggering of the circuit from stray fields from house or car electrics.

An audio amplifier, IC1, is employed for its lightly biased inputs – also for its output, which is quiescent at half the supply voltage (the author used the 8-pin version of the LM380N). As a voltage is generated across coil L1 through magnetic induction (that is, rotation of the circuit or rotation of a magnet near the circuit), IC1's output moves high or low. Capacitor C2 provides AC coupling between IC1 and IC2, and R1 stabilises the first stage of the IC2-based amplifier. IC2 is a digital CMOS IC, but one that is wired as a three-stage analogue amplifier. Its unused inputs (IC2d to IC2f) need to be 'tied high' for stability.

Op amp IC3 is wired as a comparator, and negative feedback through resistor R6 boosts its sensitivity. Preset VR1 may be adjusted so that the output of IC3 is normally high or normally low. LED1 may be replaced with an opto-coupler if the Earth Magnetometer is to switch external circuits. A reed relay will work in this position, but the loading is likely to significantly reduce the sensitivity of the circuit. Note that any electromagnetic relay needs to be mounted far from coil L1. LED1 is an ultrabright LED. A regulated power supply is recommended.

The coil L1 is described here for the sake of a repeatable circuit – however, the windings of a large transformer (say 12V 2A) are likely to work better. L1 is 1200 turns of 0.315mm diameter enamelled copper wire (30swg/22awg) on a 6mm, 25mm long steel bolt. Two 32mm-diameter washers serve as 'end-stops'. A nut holds the washers in place.

At switch-on, the circuit requires up to a minute to fully stabilise. Initial set-up may be done by turning the circuit 360° within the earth's magnetic field, and carefully adjusting VR1 around its mid-point.

The circuit has a wide range of possible applications. It would detect the rotation of a vehicle in the street, and could thus serve as an anti-theft device. It could detect the rotation of a nearby magnet, and could thus report the relative movement of objects on which a magnet is mounted. It could detect certain kinds of object underground; or experimenters could set it up as a sensitive seismometer.

Thomas Scarborough, South Africa

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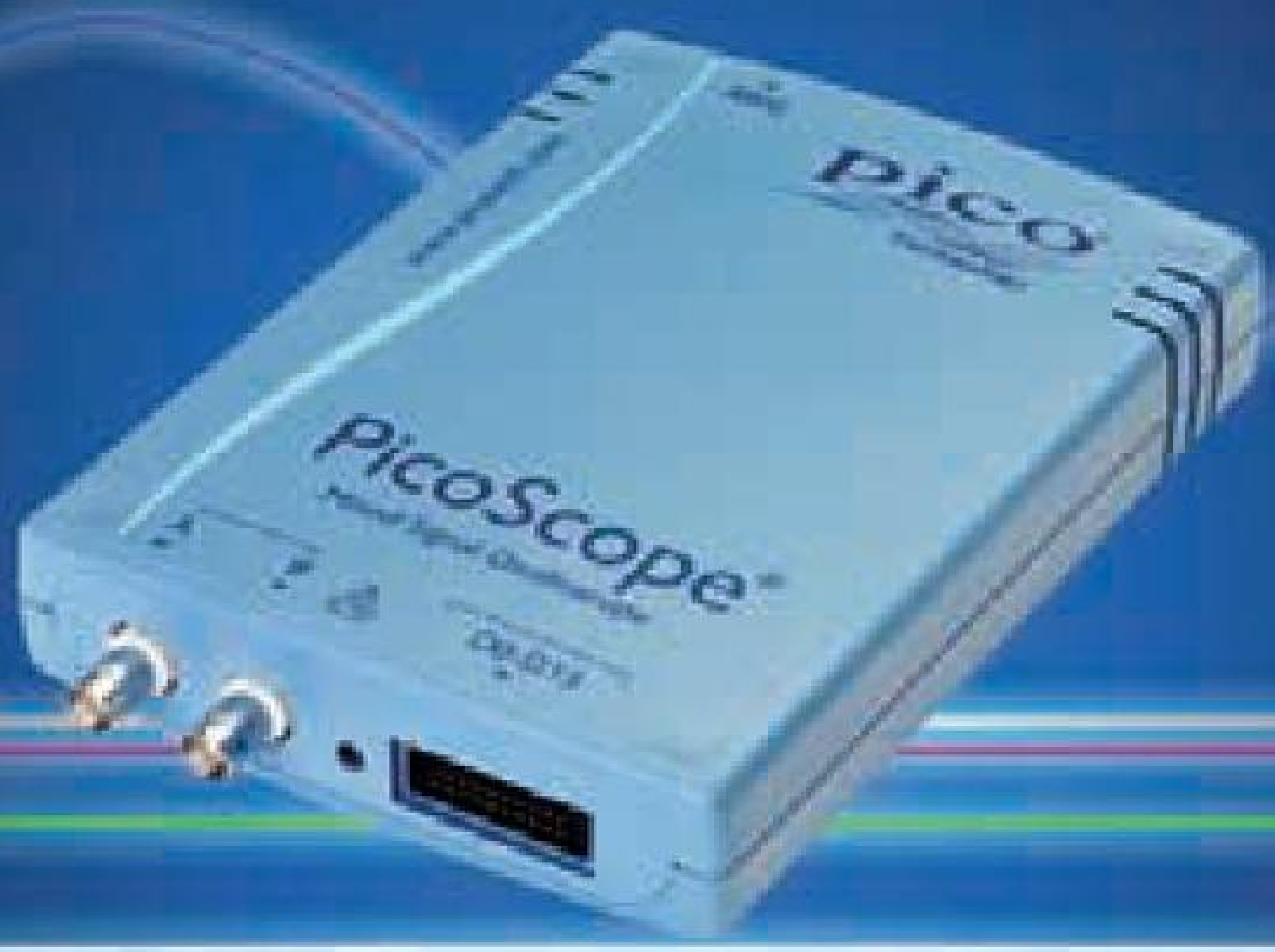

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NET WORK

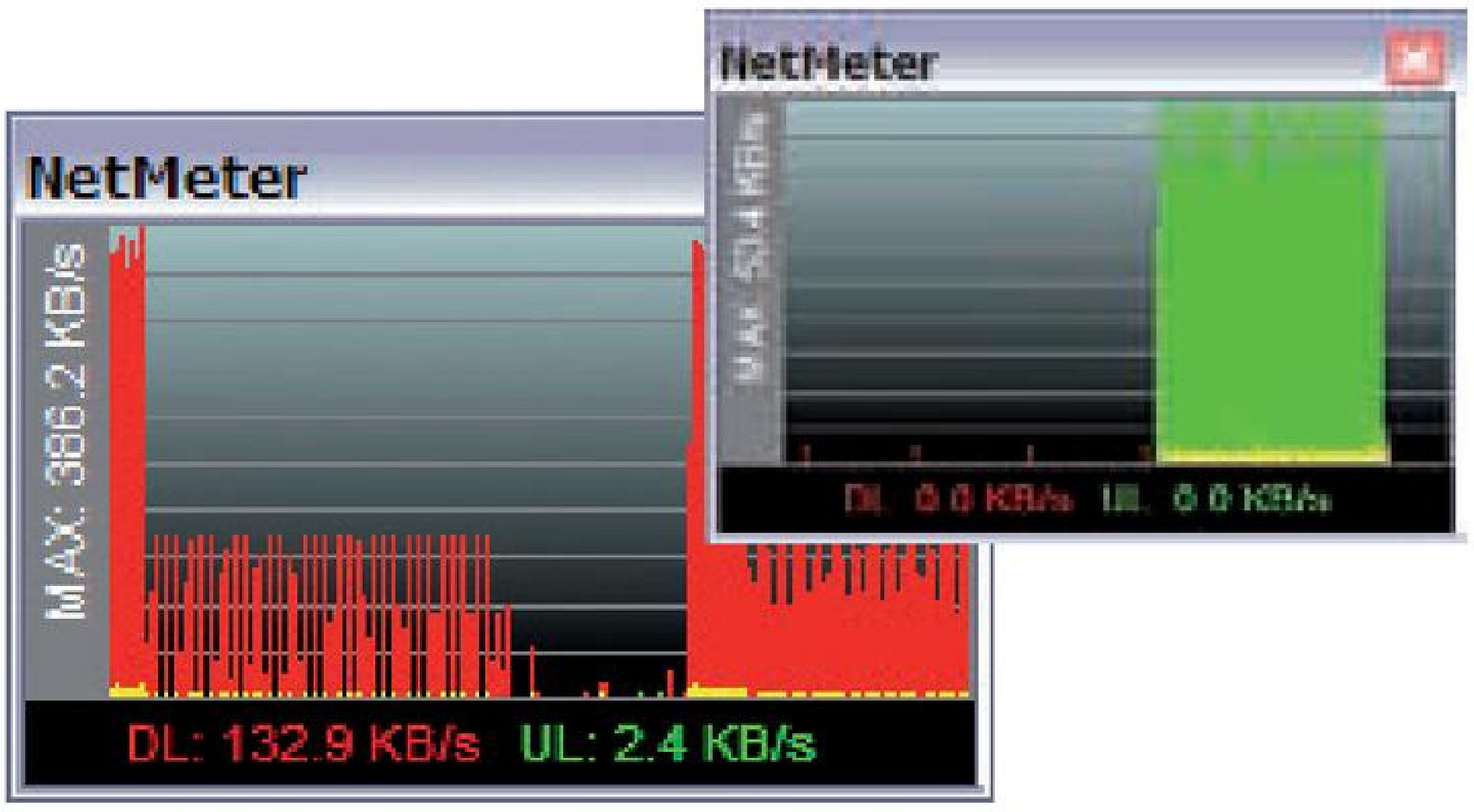
by Alan Winstanley

Window shopping

I'VE recently decided that the time is ripe to build myself a new PC. After seven years of sterling service, one of my home-brew Windows XP machines is groaning under the pressure of daily surfing, running anti-virus programs in the background and coping with all sorts of digital detritus that has been acquired over the years. After a strip-down, the redundant PC is being relegated down the household's pecking order and a new Windows 7 machine will take its place, bringing the benefits of Internet Explorer 9 and (later) IE 10 (neither of which will run in Windows XP), better productivity, faster boot-up times and the end of the hard-disk thrashing that preceeds the opening of programs and 20-second freeze-ups if you right-click on something.

The laws of diminishing returns being what they are, inevitably support for Windows XP will dwindle, and with Windows 7 gaining many plaudits, the tipping point is fast approaching when older hardware can finally be pensioned off in favour of more rewarding and future-proof technologies. However, I don't believe in putting all my eggs in one basket and I spread my workload across several PCs as much as I can. Windows XP is over a decade old and is still perfectly fine for many applications, including some very expensive programs that I have no desire to upgrade: I'll run them into the ground on another 'spring-cleaned' XP machine until it too gives up the ghost. The same is true of my accounts system, which hums along on a tough old Windows 98 box, accessible using a KVM (keyboard-video-monitor) switch. (I explained in previous columns how a W98 machine can share an NTFS network drive for data backup purposes.)

If you're thinking of simply upgrading a PC to W7 then plenty of guidance is available online, including the Microsoft Windows 7 Compatibility Center at **http://tinyurl.com/yhs5gab** which opines about popular hardware and software. Modern high-end Windows 7 systems can run Windows XP as a 'virtual PC' for retro-compatibility, provided that virtualisation hardware is onboard (namely, Intel Virtual Technology). A Windows 7 Upgrade Advisor may help anticipate any hardware issues, and can be downloaded free from **http://tinyurl.com/6873sev**.



NetMeter indicates network traffic activity in a simple graph – the green block shows Carbonite backing up data to their server, the red (download) band is a YouTube download

Flooding the market

I'm quite picky about what I use, and in preparation for building a new system a short-list of PC components has been compiled. Interestingly, hard disk prices have been in turmoil since the last quarter of 2011, and prices have actually increased considerably. My records show that 18 months ago a typical 1TB hard disk cost £37 ($55): a similar drive recently peaked at triple that price. Severe flooding at a hard disk plant in Thailand caused the price hike, when last October a Western Digital facility was flooded out and scuba divers rescued the production lines from total oblivion. Production is slowly coming onstream (no pun intended) again, but retail prices remain considerably higher than they were a year ago.

Disk drive manufacturers can switch production to other global sites, but for most home-users or smaller businesses, the loss of just a single hard disk can cause severe inconvenience if not spell total disaster. I have seen horror stories in this field, including a company that propped its backup data cartridges on a windowledge, clearly visible from the pavement outside, and a business whose database server contained two critical hard disks hanging out on cables, resting on the desk. News stories constantly leak out about critical data disks, laptops or USB drives being mislaid by civil servants or employees. I recently rescued five DVD's worth of precious photos and documents from a friend's laptop drive, as she had no backups anywhere. It makes sense to take external backups of valuable data, so in this month's *Net Work* I revisit the topic of online storage services.

I have used Carbonite for several years as a 'last gasp' backup, to be called upon in case everything else fails. Carbonite is optimised for data or documents and its software integrates well into Windows Explorer, but it has some restrictions on the type of files that it will upload (see **www.carbonite.co.uk/try-carbonite/faq**). We also found (scarcely mentioned by Carbonite) that it does not back up data hosted on a network drive. It offers unlimited storage space, but the software licence is tied to an individual PC or Mac; in a rolling process, files are backed up shortly after they change rather than awaiting a scheduled backup. (A handy program called NetMeter can help you monitor this background traffic – the green block in the screenshot is Carbonite suddenly kicking in at a quiet time and uploading the latest data to its servers, the red block is a YouTube download. NetMeter is free from **www.metal-machine.de/readerror/**).

Files can be accessed from elsewhere using the Remote Access service via Carbonite's website. Bear in mind that, like many such backup systems, if you accidentally corrupt essential data then your 'good' backup might be corrupted automatically in due course. You cannot undo this after it happens and you risk losing your critical data altogether in such circumstances; so, if necessary, you should 'freeze' your Carbonite account to protect any existing backup files. When synchronising, Carbonite also eventually deletes files that you remove from your local system. Carbonite's prices start at £41.95 a year.

Moseying around

Mozy (**www.mozy.com**) is an alternative cloud-based data backup system that works in a similar way, but is more suited to IT-confident users and it has a subscription model based on storage space usage. If network drive and server support are required, then Mozy Pro is worth looking at.

Apart from dedicated backup services being available, cloud-based storage enables users to host their own data or backup files online, and some allow public and personal file areas to be created. For example, HiDrive from the German ISP Strato offers 5GB of free online storage as well as paid-for packages starting at under £7 a month. Simply create some logins on their homepage (**https://www.free-hidrive.com**) and you can then immediately upload files to your public or private area via the HiDrive control panel.

Frustratingly, I wasted a lot of time by downloading and trying to run Hi-Drive's Windows software, only to eventually find that it's irrelevant to XP users. Windows 7 users will probably have a better experience, as the disk space can be given a simple drive letter, but in Windows XP simply use the My Network Connections/ Add Network Place wizard and point to your free space (eg, **https://yourusernamehere.webdav.hidrive.strato.com**)/ and log into it with your username and password. In XP, the HiDrive then appears as a Web Folder in Windows Explorer, and files can be dragged and dropped onto it from the desktop.

Another attraction for the writer was that HiDrive offers an app for the Synology network-attached storage (NAS) drive that I've mentioned in previous columns. This offers the prospect of uploading files directly from the NAS drive onto the HiDrive cloud, but disappointingly the app cannot be used with the free HiDrive service.

Amazon provides an online storage service called Amazon Cloud. Known for its very robust and scalable cloud storage architecture, Amazon Cloud offers 5GB of free space but an Amazon.com US account is needed (which is easily arranged) as a .co.uk account won't work. Simply check in with your Amazon US logins and begin uploading to a folder (filesize 2GB maximum) via your web browser. MP3 downloads purchased from Amazon can be backed up automatically, for free. Extra space costing $1 per gigabyte per year is offered, up to a maximum of 1TB costing $1,000. A 20GB/ $20 annual package on Amazon Cloud might be sufficient for many readers to store their most precious documents or files. See **https://www.amazon.com/clouddrive/learnmore**.

Unfortunately, my Synology NAS does not currently support Amazon Cloud either. However, for more intensive use, data from the Synology NAS could be uploaded to Amazon's S3 (Simple Storage Service), an industrial-strength application intended for developers or advanced IT users. More details at **http://aws.amazon.com/s3/**

A widening and more flexible choice of online storage options is emerging as the Internet integrates ever more tightly into both the computer's operating system and the peripherals sharing the same local network. The biggest bottleneck is currently the lack of bandwidth, with many users still handicapped by their ADSL offering maybe 2 to 3 megabits per second. Even so, backing up to the cloud makes more sense than ever, especially if your valuable collection of family photos, student notes, personal documents or music is not insured against loss. Why not check out some of the online services suggested and grab some free gigabytes for yourself.

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Digging deep

Think of online video storage and YouTube soon springs to mind. They are the world's premier site for hosting personal and corporate videos, and among the 'noise' many interesting clips will be found, including old commercials, fascinating documentaries, music videos and news clips. You can upload videos to your YouTube account from a PC, or use your mobile phone camera directly – keeping an eye on your mobile data tariff though.

Viewing YouTube videos in a web browser, or with a Windows Mobile app or on a TV screen using the Humax digital PVR that I covered last year, is all well and good, but I recently found myself grappling with the problem of how to save them onto hard disk for viewing offline later. At the same time, I thought about archiving online TV content as well: major TV channels have a streaming output (BBC iPlayer, Channel 4OD etc) and sometimes if I miss a broadcast I might like to record an online repeat and burn it onto DVD for future reference. (A twin-tuner TV card such as a Hauppauge PVR installed in your computer can also be used to schedule and record real-time TV transmissions to hard disk.)

Making a videotape (yes!) of BBC TV iPlayer programmes, captured through the Humax TV Portal TV, is one answer, but my pile of DVD 'coasters' are testimony to the fact that iPlayer's rights protection carries through to the DVD recorder, and TV programmes cannot readily be burned onto disc. After surfing around the web I came across TubeDigger, a neat Windows program that claims to download online video from any website, including YouTube, iPlayer and 4OD. With some scepticism I installed the trial and found that it did indeed fetch Flash-based online video from the likes of 4OD and YouTube, saving them on disk as .flv files.

Tubedigger behaves like a simple web browser, and you simply navigate to eg YouTube or 4OD and search for your file. Recording can start when the video starts playing and a slew of .flv files is created (including station idents, trailers and commercials). It can be left to download batches of files in tandem.

Afterwards, TubeDigger's built-in media converter can output .avi files, MP4s and various formats for the iPod, Sony PSP and more. The audio track can be saved on its own if you enjoy listening to podcasts. As usual, video conversion is a time-consuming chore and a DVD burning program such as Nero is needed to create a playable DVD, which takes even more time. I found that the resulting home-brew DVDs were very temperamental when I tried them on an old DVD player, but they played faultlessly on a new one.

So far, TubeDigger has done what it says on the wrapper and the cost of $24.95 for five licence 'seats' seems very reasonable. A trial can be downloaded from **www.tubedigger.com**. Try it on some YouTube videos that interest you and see if it works for you.

See you next month for more Net Work. You can email the author at **alan@epemag.demon.co.uk** or write to **editorial@wimborne.co.uk** for possible inclusion in *Readout*, and you might win a prize!

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The CD-ROM also contains all of the software for the *Teach-In 2* series and *PIC N' Mix* articles, plus a range of items from Microchip – the manufacturers of the PIC microcontrollers. The material has been compiled by Wimborne Publishing Ltd. with the assistance of Microchip Technology Inc.

The Microchip items are: MPLAB Integrated Development Environment V8.20; Microchip Advance Parts Selector V2.32; Treelink; Motor Control Solutions; 16-bit Embedded Solutions; 16-bit Tool Solutions; Human Interface Solutions; 8-bit PIC Microcontrollers; PIC24 Mircontrollers; PIC32 Microcontroller Family with USB On-The-Go; dsPIC Digital Signal Controllers.

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The three sections of this book cover a very wide range of subjects that will interest everyone involved in electronics, from hobbyists and students to professionals. The first 80-odd pages of Teach-In 3 are dedicated to *Circuit Surgery*, the regular *EPE* clinic dealing with readers' queries on various circuit design and application problems – everything from voltage regulation to using SPICE circuit simulation software.

The second section – *Practically Speaking* – covers the practical aspects of electronics construction. Again, a whole range of subjects, from soldering to avoiding problems with static electricity and indentifying components, are covered. Finally, our collection of *Ingenuity Unlimited* circuits provides over 40 circuit designs submitted by the readers of *EPE*.

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128 pages **Order code BP722** **£7.99**

PROGRAMMING 16-BIT PIC MICROCONTROLLERS IN C – LEARNING TO FLY THE PIC24 Lucio Di Jasio (Application Segments Manager, Microchip, USA)

A Microchip insider tells all. Focuses on examples and exercises that show how to solve common, real-world design problems quickly. Includes handy checklists to help readers perform the most common programming and debugging tasks. FREE CD-ROM includes source code in C, the Microchip C30 compliler, and MPLAB SIM software, so that readers gain practical, hands-on programming experience.

Until recently, PICs didn't have the speed and memory necessary for use in designs such as video- and audio-enabled devices. All that changed with the introduction of the 16-bit PIC family, the PIC24. This new guide teaches readers everything they need to know about the architecture of these chips, how to program them, how to test them and how to debug them. Lucio's common-sense, practical, hands-on approach starts out with basic functions and guides the reader step-by-step through even the most sophisticated programming scenarios.

Experienced PIC users and newcomers alike will benefit from the text's many thorough examples, which demonstrate how to nimbly side-step common obstacles and take full advantage of all the 16-bit features.

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128 pages **Order code BP721** **£7.99**

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BASIC RADIO PRINCIPLES AND TECHNOLOGY
Ian Poole

Radio technology is becoming increasingly important in today's high technology society. There are the traditional uses of radio which include broadcasting and point to point radio as well as the new technologies of satellites and cellular phones. All of these developments mean there is a growing need for radio engineers at all levels.

Assuming a basic knowledge of electronics, this book provides an easy to understand grounding in the topic.

Chapters in the book: Radio Today, Yesterday, and Tomorrow; Radio Waves and Propagation; Capacitors, Inductors, and Filters; Modulation; Receivers; Transmitters; Antenna Systems; Broadcasting; Satellites; Personal Communications; Appendix – Basic Calculations.

263 pages **Order code NE30** **£28.99**

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3 **All prices include UK postage**

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NEW FULL COLOUR COMPUTING BOOKS

WINDOWS 7 – TWEAKS, TIPS AND TRICKS

Andrew Edney

This book will guide you through many of the exciting new features of Windows 7. Microsoft's latest and greatest operating system. It will provide you with useful hints, tips and warnings about possible difficulties and pitfalls. This book should enable you to get much more out of Windows 7 and, hopefully, discover a few things that you may not have realised were there.

Among the topics covered are: A brief overview of the various versions of Windows 7. How to install and use Upgrade Advisor, which checks to see if your computer meets the minimum requirements to run Windows 7 and that your software and drivers are supported by Windows 7. How to use Windows Easy Transfer to migrate your data and settings from your Vista or XP machine to your new Windows 7 computer. Exploring Windows 7 so that you will become familiar with many of its new features and then see how they contrast with those of earlier versions of Windows. How to connect to a network and create and use Home Groups to easily share your pictures, videos, documents, etc.,with the minimum of hassle. Why Windows Live Essentials is so useful and how to download and install it. A brief introduction to Windows Media Center. The use of Action Center, which reports security and maintenance incidents. Windows Memory Diagnostic to detect the fairly common problem of faulty memory and Troubleshooting tools.

120 pages **Order code BP708** **£8.49**

HOW TO BUILD A COMPUTER MADE EASY

R.A. Penfold

Building your own computer is a much easier than most people realise and can probably be undertaken by anyone who is reasonably practical. However, some knowledge and experience of using a PC would be beneficial. This book will guide you through the entire process. It is written in a simple and straightforward way with the explanations clearly illustrated with numerous colour photographs.

The book is divided into three sections: *Overview and preparation* – Covers understanding the fundamentals and choosing the most suitable component parts for your computer, together with a review of the basic assembly. *Assembly* – Explains in detail how to fit the component parts into their correct positions in the computer's casing, then how to connect these parts together by plugging the cables into the appropriate sockets. No soldering should be required and the only tools that you are likely to need are screwdrivers, small spanners and a pair of pliers.

BIOS and operating system – This final section details the setting up of the BIOS and the installation of the Windows operating system, which should then enable all the parts of your computer to work together correctly. You will then be ready to install your files and any application software you may require.

The great advantage of building your own computer is that you can 'tailor' it exactly to your own requirements. Also, you will learn a tremendous amount about the structure and internal workings of a PC, which will prove to be invaluable should problems ever arise.

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AN INTRDUCTION TO eBAY FOR THE OLDER GENERATION

Cherry Nixon

eBay is an online auction site that enables you to buy and sell practically anything from the comfort of your own home. eBay offers easy access to the global market at an amazingly low cost and will enable you to turn your clutter into cash.

This book is an introduction to eBay.co.uk and has been specifically written for the over 50s who have little knowledge of computing. The book will, of course, also apply equally to all other age groups. The book contains ideas for getting organised for long term safe and successful trading. You will learn how to search out and buy every conceivable type of thing.The book also shows you how to create auctions and add perfect pictures. There is advice on how to avoid the pitfalls that can befall the inexperienced.

Cherry Nixon is probably the most experienced teacher of eBay trading in the UK and from her vast experience has developed a particular understanding of the issues and difficulties normally encountered by individuals.

So, if you are new to computers and the internet and think of a mouse as a rodent, then this is the book for you!

120 pages **Order code BP709** **£8.49**

GETTING STARTED IN COMPUTING FOR THE OLDER GENERATION

Jim Gatenby

You can learn to use a computer at any age and this book will help you acheive this. It has been especially written for the over 50s, using plain English and avoiding technical jargon wherever possible. It is lavishly illustrated in full colour.

Among the many practical and useful subjects that are covered in this book are: Choosing the best computing system for your needs. Understanding the main hardware components of your computer. Getting your computer up and runnning in your home. Setting up peripheral devices like printers and routers. Connecting to the internet using wireless broadband in a home with one or more computers. Getting familiar with Windows Vista and XP the software used for operating and maintaining your computer. Learning about Windows built-in programs such as Windows Media Player, Paint and Photo Gallery.

Plus, using the Ease of Access Center to help if you have impaired eyesight, hearing or dexterity problems. Installing and using essential software such as Microsoft Office suite. Searching for the latest information on virtually any subject. Keeping in touch with friends and family using e-mail. Keeping your computer running efficiently and your valuable data files protected against malicious attack.

This book will help you to gain the basic knowledge needed to get the most out of your computer and, if you so wish, give you the confidence to even join a local computer class.

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Third Edition

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New chapter on PIC microcontrollers – the most popular chip family for use in project work by hobbyists and in colleges and universities.

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The unique combination of a comprehensive reference text, incorporating a primary focus on practical applications, ensures this text will prove a vital guide for students and also for industry-based engineers, who are either new to the field of electronics, or who wish to refresh their knowledge.

400 pages **Order code NE43** **£25.99**

BEBOP TO THE BOOLEAN BOOGIE

Third Edition

Clive (Max) Maxfield

This book gives the 'big picture' of digital electronics. This indepth, highly readable, guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate.

Contents: Fundamental concepts; Analog versus digital; Conductors and insulators; Voltage, current, resistance, capacitance and inductance; Semiconductors; Primitive logic functions; Binary arithmetic; Boolean algebra; Karnaugh maps; State diagrams, tables and machines; Analog-to-digital and digital-to-analog; Integrated circuits (ICs); Memory ICs; Programmable ICs; Application-specific integrated circuits (ASICs); Circuit boards (PWBs and DWBs); Hybrids; Multichip modules (MCMs); Alternative and future technologies.

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Clive (Max) Maxfield and Alvin Brown

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FUNDAMENTAL ELECTRICAL AND ELECTRONIC PRINCIPLES

Third Edition

C. R. Robertson

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The book explains all theory in detail and backs it up with numerous worked examples. Students can test their understanding with end of chapter assignment questions for which answers are provided. In this new edition, the layout has been improved and colour has been added. A free companion website with additional worked examples and chapters is also available.

368 pages **Order code NE47** **£21.99**

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Keith Brindley

Starting Electronics is unrivalled as a highly practical introduction for technicians, non-electronic engineers, software engineers, students, and hobbyists. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits. Breadboard layouts make this very much a ready-to-run book for the experimenter, and the use of readily available, inexpensive components makes this practical exploration of electronics easily accessible to all levels of engineer and hobbyist.

Other books tell readers what to do, but sometimes fail to explain why - Brindley gives readers hands-on confidence in addition to real scientific knowledge, and insight into the principles as well as the practice. All written explanations and steps are supplemented with numerous photos, charts, tables and graphs. Concepts and practical aspects are explained thoroughly with mathematical formulae and technical schematic drawings.

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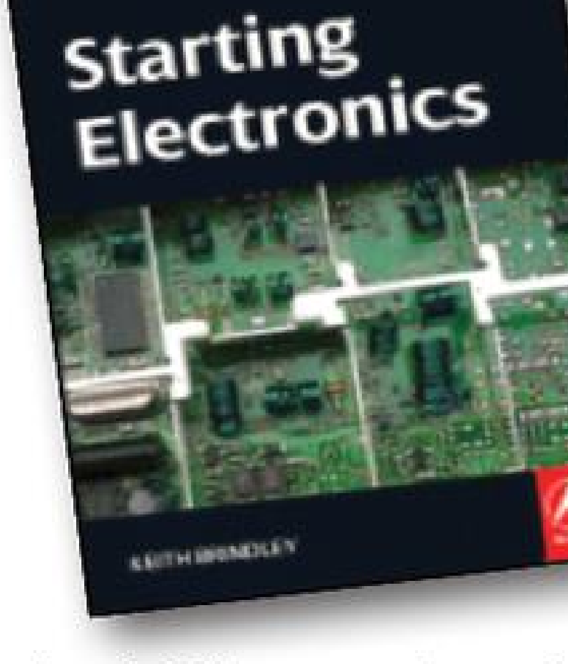

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Stephen Bennett

Nearly everyone with musical aspirations also has a computer. This same computer can double as a high quality recording studio capable of producing professional recordings. This book tells you what software and hardware you will need to get the best results.

You'll learn about recording techniques, software and effects, mixing, mastering and CD production.

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92 pages **Order code PC120** **£10.95**

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Ian Waugh

MP3 files, the latest digital music format, have taken the music industry by storm. What are they? Where do you get them? How do you use them? Why have they thrown record companies into a panic? Will they make music easier to buy? And cheaper? Is this the future of music?

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Whether you want to stay bang up to date with the latest music or create your own MP3s and join the on-line digital music revolution, this book will show you how.

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It explains:

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- Sound and digital audio essentials
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- The art of mixing
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- How to use virtual instruments
- How to edit audio and create loops

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For details see the UK shop on our web site at www.epemag.com or contact us for a list of *Radio Bygones* books.

PROJECT BUILDING AND TESTING

ELECTRONIC PROJECT BUILDING FOR BEGINNERS

R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

135 pages **Order code BP392** **£5.99**

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Morgan Jones

The practical guide to building, modifying, fault-finding and repairing valve amplifiers. A hands-on approach to valve electronics – classic and modern – with a minimum of theory. Planning, fault-finding, and testing are each illustrated by step-by-step examples.

A unique hands-on guide for anyone working with valve (tube in USA) audio equipment – as an electronics experimenter, audiophile or audio engineer.

Particular attention has been paid to answering questions commonly asked by newcomers to the world of the vacuum tube, whether audio enthusiasts tackling their first build, or more experienced amplifier designers seeking to learn the ropes of working with valves. The practical side of this book is reinforced by numerous clear illustrations throughout.

368 pages **Order code NE40** **£29.00**

PRACTICAL FIBRE-OPTIC PROJECTS

R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

GETTING THE MOST FROM YOUR MULTIMETER

R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

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Next Month

Content may be subject to change

These days, almost everyone has a DMM (digital multimeter) and in the April issue we offer two exciting projects to extend their functionality.

Capacitor Leakage Adaptor for DMMs

Here's a cut-down version of the Digital Capacitor Leakage Meter we described in November 2011. Instead of using a PIC microcontroller and an LCD panel to display the leakage current, this version connects to your DMM to provide the readout. It provides the same range of seven different standard test voltages (from 10V to 100V) and can measure leakage currents down to 100 nanoamps!

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High-Quality Digital Audio Signal Generator – Part 2

In the March issue, we described how the S/PDIF Digital Audio Signal Generator works. Next month, we describe how to assemble the PC boards, mount them in the case and check that they are working correctly.

WIB FAQs

Our recent Web Server In a Box (WIB) project has been very popular and lots have been built. Here we collect a number of frequently asked questions (FAQs) to help anyone experiencing difficulties in building and setting up the WIB. We also provide the answers to some common technical questions and feature requests.

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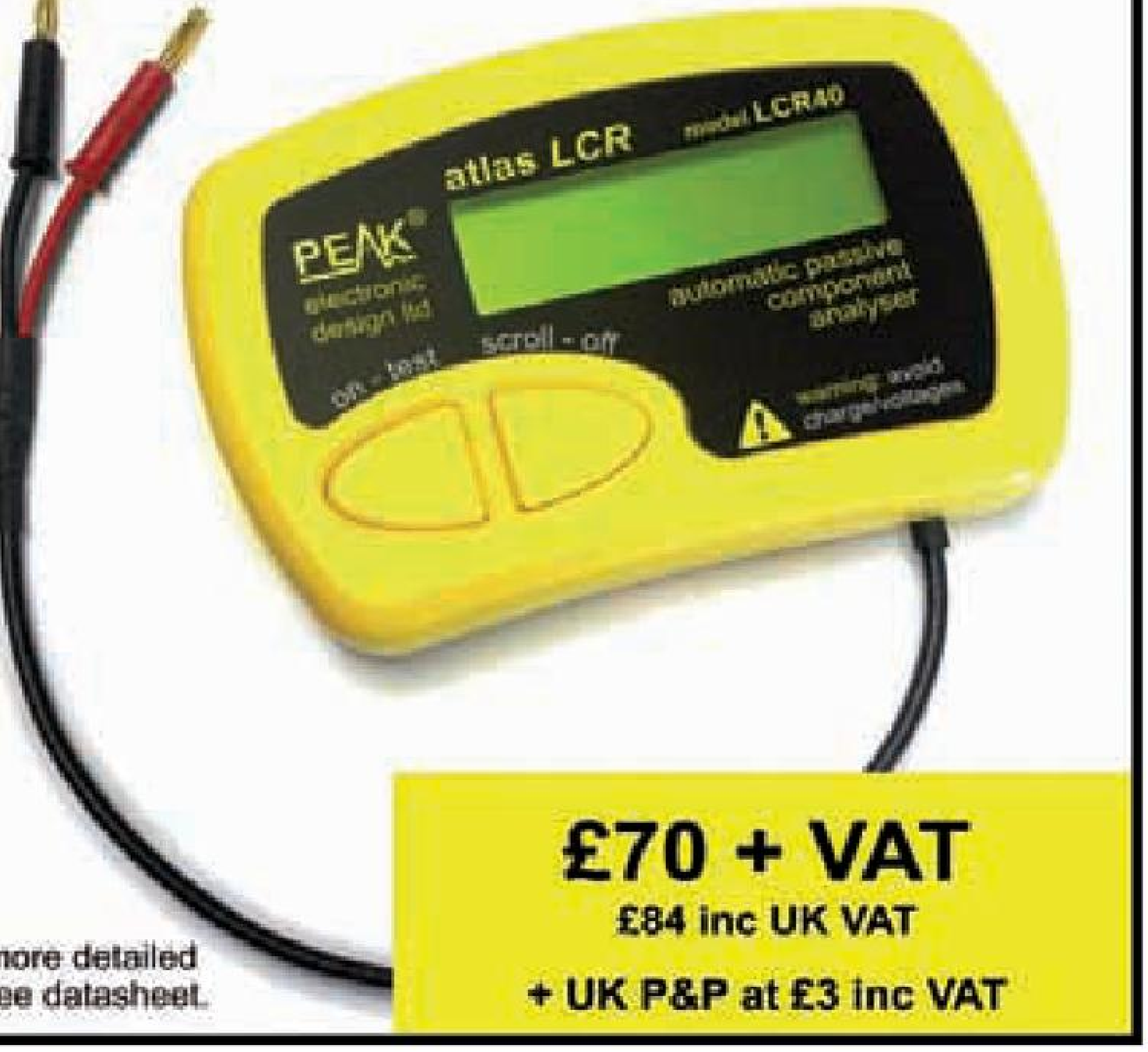
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